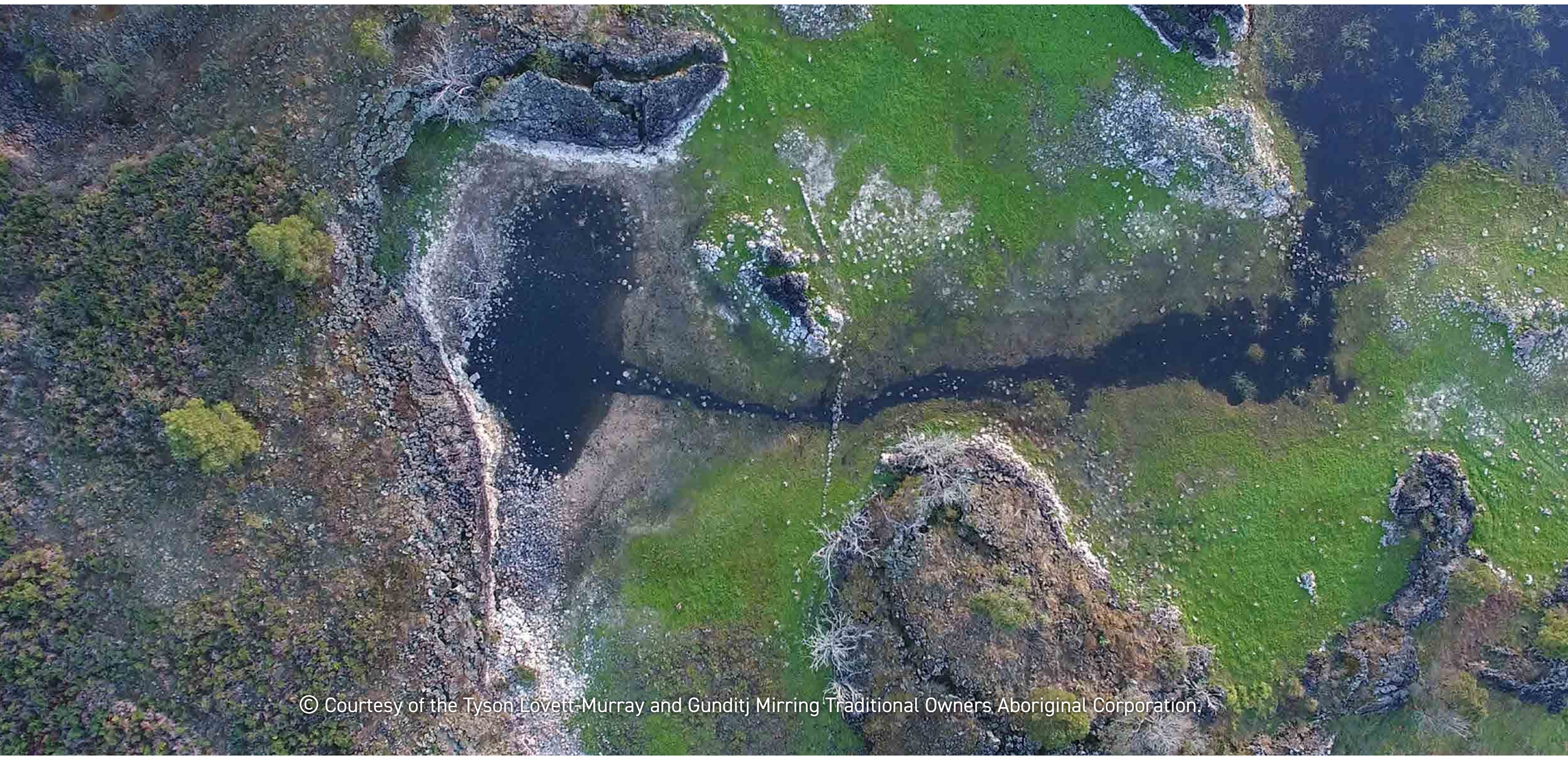
Commissioner
for Environmental
Sustainability
Victoria

Victorian State of the Environment 2023 Report
Scientific Assessments Volume 2

VICTORIA
State
Government



Aerial view of Tae Rak channel and holding pond, Budj Bim Cultural Landscape Gunditjmara Country of south-western Victoria. In 2019, Budj Bim Cultural Landscape became one of only 20 World Heritage sites in Australia listed by the United Nations Educational, Scientific and Cultural Organization (UNESCO).

The Budj Bim Cultural Landscape is the first Australian Aboriginal cultural site to be added exclusively for its cultural significance. Over the past 40 years, the Gunditjmara Traditional Owners have recovered ownership of several properties spanning the coastal aquaculture system, discovering the complexity of the network. At this site is evidence of sophisticated Aboriginal engineering practices. Budj Bim is a vast and complex aquaculture system consisting of constructed dams, ponds and channels designed to direct and store eels and other fish for routine harvesting. It is archaeologically dated at 6,600 years of continuous use. Budj Bim was built on principles of respect for Country and was constructed to support a concentrated population. It required precision in construction to manage water flow, and an in-depth understanding of natural processes. There are many known Aboriginal engineering sites around Australia.

Traditional Owners

We acknowledge and respect Victoria's Traditional Owners as the original custodians of Victoria's land and waters. We acknowledge their unique ability to care for Country and their deep spiritual connection to it.

We honour Elders past and present, whose knowledge and wisdom have ensured the continuation of culture and traditional practices.

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Cover Image: Mount Buffalo National Park.
Credit: Christian Pearson. © Parks Victoria.

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Guide to indicator assessments

Each indicator report card includes the following information.

Measures

These are the specific measurements and data sets used to inform the status and trend assessments.

Region

The assessments have been conducted on a statewide and/or regional scale based on the localisation of the impacts associated with each indicator and/or the spatial scale of the evidence supporting the assessment.

Status

The status summary presents an overall analysis of the assessment for each indicator. An indicator can be assessed as having a good, fair or poor status (see status thresholds below). Where there is insufficient data, the indicator status is assessed as unknown. Note that some indicators may not show discernible changes over the 5-year period that is used for state of the environment reporting, thus, the assessment for these indicators incorporate changes in environmental condition over longer time scales (e.g. decadal).

The legend for status in the report card is:

- **Good:** Environmental condition is healthy across Victoria, OR pressure is likely to have negligible impact on environmental condition/human health, OR comprehensive protection of natural ecosystems and biodiversity is evident.
- **Fair:** Environmental condition is neither positive nor negative and may be variable across Victoria, OR pressure is likely to have limited impact on environmental condition/ human health, OR moderate protection of natural ecosystems and biodiversity is evident.
- **Poor:** Environmental condition is under significant stress, OR pressure is likely to have significant negative impact on environmental condition/ human health, OR inadequate protection of natural ecosystems and biodiversity is evident.
- **Unknown:** Data are insufficient to assess status or trend.
- **N/A (not applicable):** An indicator status assessment has not been made, because this indicator is not relevant for this region or because the assessment of status is inappropriate for the indicator.

🟢	🟡	🔴	●	N/A	N
Good	Fair	Poor	Unknown	Not Applicable	Narrative but not assessed

Trend

The trend summary presents an overall analysis of the trend assessments for each selected indicator. The trend identifies whether the status of the indicator is deteriorating, improving or remaining stable. Importantly, trend does not represent whether the measure used to assess the indicator is increasing or decreasing (e.g. increasing waste generation) but instead reflects whether the change in the indicator measure denotes an improved or deteriorating environmental outcome.

The legend for trend in the report card is:

- **Improving**
- **Stable**
- **Deteriorating**
- **Unclear**
- **N/A Not applicable:** This indicator assessment is based on current environmental condition only and it is not applicable to provide a trend assessment. Only a Status assessment is provided.

↗	→	↙	?	N/A	N
Improving	Stable	Deteriorating	Unclear	Not Applicable	Narrative but not assessed

Confidence

Confidence reflects on knowledge gaps and data limitations when assessing the status and trend of the indicator.

Note that in the SoE 2018 Report, the quality of data for each indicator was assessed as either good, fair or poor. The ratings given to data quality in 2018 are included in the summary table for each indicator in this chapter. However, the 2023 assessment does not refer to data quality in the summary table. Instead, it refers to confidence in the assessment of status and trend, rating it as either low, moderate, high or insufficient. The change to providing an assessment of indicator confidence rather than data quality in 2023 has been made to reflect that data quality is one of several components that inform the confidence of indicator status and trend assessments – other components include the level of scientific consensus and the presence of scientifically-developed thresholds, legislative objectives or existing reporting frameworks.

The legend for confidence in the report card is:

- **High:** Adequate high-quality evidence and high-level of consensus.
- **Moderate:** Limited evidence or limited consensus.
- **Low:** An assessment can be made, but there is only minimal evidence to guide the assessment.
- **Insufficient:** There is negligible evidence (that is, suitable data and/or thresholds) and no status and trend assessments can be made.
- **N/A (not applicable):** An indicator data confidence assessment has not been made because status and trend assessments were unable to be made.

🟢	🟡	🔴	●	N/A	N
High	Moderate	Low	Insufficient	Not Applicable	Narrative but not assessed

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Forests (Fo)

Victorian State of the Environment 2023 Report

Woowookarung Regional Park.
Credit: Peter Kerbarec.
© Parks Victoria.

Key findings

Forests, and the services they provide, are essential for the health and wellbeing of all Victorians. Forests maintain Victoria's water quality, purify the air, store carbon, stabilise and nourish the soil, assist agriculture, and support economies that are vital for regional communities and businesses. Forests are critical habitats for biodiversity, especially for the conservation of many iconic threatened species in Victoria. Forests have been an essential part of the history and culture for Victoria's Traditional Owners and Aboriginal Victorians.

Various forest values deteriorated in this state of the environment reporting period (2018–22) compared to the previous period (2013–18), primarily because of the 2019-20 bushfires (Table Fo1). Nearly 1.4 million hectares of native forest — or 18% of Victoria's public native forests — were burnt.[1233, 1234] This directly impacted the assessments for many indicators, including forest fragmentation, forest-dependent species, expansion of invasive species and timber harvest areas successfully regenerated previously.

The 2019-20 bushfires had a significant impact on forest-dependent species (Fo:06), resulting in their status changing from fair to poor with a deteriorating trend. Of the VEAC's 84 threatened forest-dependent species, 32 (DELWP's species of most concern) were directly impacted by the high-severity fires or had some of their modelled habitat within the fire extent. Fifteen species had more than 50% of their extent burnt and the following listed species were exposed to high-severity fires across more than 50% of their overall extent: Betka bottlebrush, roundsnout galaxias, East Gippsland galaxias, Mallacoota burrowing crayfish, Orbost spiny crayfish and eastern she-oak skink. Another two listed species — the diamond python and the large brown tree frog — have had at least 50% of their habitat impacted by multiple high-severity fires since 2000.

Forest fragmentation (Fo:04) is a critical indicator for monitoring biological diversity. Due to the technical difficulties in ensuring accuracy, only a state-scale comparison was possible. The state data from 2018 and 2022 demonstrates a large increase of edge (~1.3 million ha) and a decrease of interior areas (~0.7 million ha). The increase in forest edge and the decrease in the total interior area might be a result of 2019-20 bushfires as well as other factors, including change of forest extent mapping methodology and data resolution. Many species increased their genetic risk because of the 2019-20 bushfires. Because more frequent and higher intensity bushfires are expected as a result of climate change, future policy settings and interventions will be needed to tackle this trend.

In response to the 2019-20 bushfires the Victorian Government invested significantly in ex-situ and in-situ conservation efforts (Fo:05) to address the decline in the state's biodiversity. A notable conservation effort was the introduction of a variable retention harvesting method in the majority of coupes. Since 2019-20, VicForests harvested 3,281 hectares of native timber using this technique. The post-harvest monitoring program found species persist within and around harvested areas. Captive breeding programs also contributed to protecting seven threatened species released into protected habitat. These are the Leadbeater's possum, helmeted honeyeater, yellow-tufted honeyeater, plains-wanderer, eastern bristlebird, eastern barred bandicoot and orange-bellied parrot. Despite all efforts, biodiversity in forests is deteriorating.

The 2019-20 bushfires also impacted timber harvesting (Fo:12 to Fo:14). The Victorian Conservation Regulator (CR) identified 34 species of concern due to significant biodiversity loss, requiring additional protection from timber harvesting to assist recovery. These included the giant burrowing frog, greater glider, glossy black-cockatoo, Leadbeater's possum and diamond python.[1235] VicForests developed an approach to protect the species of concern. The Major Event Review on the impact of the 2019-20 bushfires on the operation of Victoria's Regional Forest Agreements (RFAs), which was released in 2022, found that the precautionary principle and tailored adaptive responses to the 2019-20 bushfires was a sound approach to mitigate the risk of serious or irreversible damage from timber harvesting.[1236] Although there is a reduction

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1233. National Emergency Management Agency, 'Bushfires – Black summer', https://knowledge.aidr.org.au/resources/black-summer-bushfires-vic-2019-20 Accessed 19 April 2023.
1234. The overall figure for the impact of the 2019-20 bushfires in Victoria is 1.5 million hectares, which includes all public and private land.
1235. Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf Accessed 21 November 2022.
1236. Ibid.

of the volume of D+ sawlog inventory due to the 2019-20 bushfires, the remaining sawlog volumes available under the current Allocation Order appear to be sufficient to meet the allowable harvesting levels under the Victorian Forestry Plan (VFP) for both ash and mixed species in eastern Victoria. These major changes in the timber harvesting method, along with sufficient timber resources, resulted in positive change in assessments for timber harvesting indicators. The revised timeline to end Victoria's native timber harvesting – by 1 January 2024, as opposed to 2030 – will address concerns about the adverse impact of native timber harvesting on biodiversity. However, ongoing management should be applied to successfully recover harvested areas that were previously regenerated, are still regenerating or were recently harvested.

The timber harvest area successfully regenerated (Fo:15) was impacted by the 2019-20 bushfires. Victoria's Department of Energy, Environment and Climate Action (DEECA) is responsible for the ongoing management of the regenerated areas once they are successfully regenerated after harvesting and removed from the Timber Release Plan (TRP). The 2019-20 bushfires impacted 82,700 hectares of ash forest; no information was available on mixed-species forest. The overall regeneration status for coupes harvested up to June 2020 that remain on the TRP shows that around 40% of 10,083 hectares that were harvested four to five years ago is yet to be finalised (i.e. regenerated). Rapid changes in the intensity and frequency of fire regimes pose significant challenges for managing and successfully regenerating forests after timber harvesting. As a result, the status of this indicator has deteriorated, from fair to poor.

The data confidence of many indicators deteriorated during this reporting period – including Fo:01B, Fo:02 and Fo:10 – due to time-series data being discontinued. Furthermore, the 2023 forest extent information was not comparable to the information in previous state of the environment reports (2013 and 2018), due to different analytical methods and image resolution, with 2023 data having a lower resolution.

Victoria's forest health is important for tackling GHG emissions (Fo:11). Victoria's land use, land-use change and forestry (LULUCF) sector was a net sink for GHGs of 21,054 CO2-e in 2020. This equates to around one-quarter of Victoria's total emissions, which is a significantly higher proportion than the national figure (7.8%). The LULUCF sector in Victoria has been increasing net sink contributions over the past 10 years.[1237]

Dandenong Ranges National Park.
Credit: Rebecca Walton. © Parks Victoria.

[1237] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian greenhouse gas emissions report', Melbourne, Victoria, https://www.parliament.vic.gov.au/file_uploads/Victorian_Greenhouse_Gas_Emissions_Report_2020_tH8912bV.pdf Accessed 6 January 2023.

Table Fo1: Forest indicators assessed in this chapter with comparisons to SoE 2018 assessments.

Forests

2023 Indicator	2023 status	2023 trend	2023 confidence	2018 Indicator	2018 status	2018 trend	2018 data quality
Ecosystem diversity							
Fo:01A Area of forest by type and tenure – forest canopy cover	⚪	?	🔴	Fo:01A Area of forest by type and tenure – forest canopy cover	⚪	?	🔴
Fo:01B Area of forest by type and tenure – forest type	⚪	?	🔴	Fo:01B Area of forest by type and tenure – forest type	🟡	↗	🟢
Fo:01C Area of forest by type and tenure – plantation forest	🔴	↙	🟡	Fo:01C Area of forest by type and tenure – plantation forest	🟡	→	🟢
Fo:02 Area of forest type by growth stage	⚪	?	🔴	Fo:02 Area of forest type by growth stage	🟡	↗	🟢
Fo:03 Area of forest type by growth stage distribution in protected zones	🟡	↗	🟡	Fo:03 Area of forest type by growth stage distribution in protected zones	🟡	↗	🟡
Fo:04 Fragmentation of native forest cover	🔴	↙	🟡	Fo:04 Fragmentation of native forest cover	🔴	?	🟡
Genetic diversity							
Fo:05 Number of in-situ and ex-situ conservation efforts for forest-dependent species	🔴	?	🟡	Fo:05 Number of in-situ and ex-situ conservation efforts for forest-dependent species	⚪	?	🔴
Species diversity							
Fo:06 Status of forest-dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment	🔴	↙	🟢	Fo:01B Area of forest by type and tenure – forest type	🟡	↙	🟢
Fo:07 Degree of disturbance to native forest species caused by invasive species	🟡	?	🟡	Fo:01C Area of forest by type and tenure – plantation forest	🟡	↙	🟢

Forests

2023 Indicator	2023 status	2023 trend	2023 confidence	2018 Indicator	2018 status	2018 trend	2018 data quality
Ecosystem health							
Fo:08A Scale and impact of agents and processes affecting forest health and vitality – mortality, dieback, canopy health	⚪	?	🟡	Fo:08A Scale and impact of agents and processes affecting forest health and vitality – mortality, dieback, canopy health	🟡	?	🟡
Fo:08B Scale and impact of agents and processes affecting forest health and vitality – bushfire-affected area and climate	🔴	↙	🟢	Fo:08B Scale and impact of agents and processes affecting forest health and vitality – bushfire-affected area and climate	🟡	↙	🟢
Fo:09A Area and type of human-induced disturbance – planned burns	🟡	↙	🟢	Fo:09A Area and type of human-induced disturbance – planned burns	🟡	?	🟢
Fo:09B Area and type of human-induced disturbance – grazing	⚪	↗	🔴	Fo:09B Area and type of human-induced disturbance – grazing	⚪	→	🔴
Carbon cycles							
Fo:10 Total forest ecosystem biomass and carbon pool by forest type, age class and successional stages	⚪	?	🔴	Fo:10 Total forest ecosystem biomass and carbon pool by forest type, age class and successional stages	🟡	?	🟡
Fo:11 Contribution of forest ecosystems to the global greenhouse gas balance	🟢	↗	🟢	Fo:11 Contribution of forest ecosystems to the global greenhouse gas balance	🔴	↗	🟢
Productive capacity							
Fo:12 Area and percentage of forest and net area of forest available and suitable for wood production	🟡	↙	🟢	Fo:12 Area and percentage of forest and net area of forest available and suitable for wood production	🔴	↙	🟢

Forests

2023 Indicator	2023 status	2023 trend	2023 confidence	2018 Indicator	2018 status	2018 trend	2018 data quality
Productive capacity							
Fo:13 Area of native forest harvested	🟡	→	🟢	Fo:13 Area of native forest harvested	🟡	→	🟢
Fo:14 Annual production of wood products from state forests compared to sustainable harvest levels	🟢 (wood products) ⚪ (firewood)	↙ (wood products) ↙ (firewood)	🟢 (wood products) 🟡 (firewood)	Fo:14 Annual production of wood products from state forests compared to sustainable harvest levels	🟡	↙	🟢
Fo:15 Proportion of timber harvest area successfully regenerated by forest type	🔴	↙	🟡	Fo:15 Proportion of timber harvest area successfully regenerated by forest type	🟡	→	🟢
Legal, institutional and economic frameworks							
Fo:16 Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests	🟡	↗	🟡	Fo:16 Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests	🟡	↗	🟡
Fo:17 Extent to which the institutional framework supports the conservation and sustainable management of forests	🟡	↙	🟢	Fo:17 Extent to which the institutional framework supports the conservation and sustainable management of forests	🟡	↙	🟡
Fo:18 Extent to which the economic framework supports the conservation and sustainable management of forests	⚪	?	🔴	Fo:18 Extent to which the economic framework supports the conservation and sustainable management of forests	🟡	?	🟡

Forests

2023 Indicator	2023 status	2023 trend	2023 confidence	2018 Indicator	2018 status	2018 trend	2018 data quality
Legal, institutional and economic frameworks							
Fo:19 Capacity to conduct and apply research and development aimed at improving forest management, including development of scientific understanding of forest ecosystem characteristics and functions	🟢	↗	🟢	Fo:19 Capacity to conduct and apply research and development aimed at improving forest management, including development of scientific understanding of forest ecosystem characteristics and functions	🟢	→	🟢
Socio-economic benefits							
Fo:20 Investment and expenditure in forest management	🟡	↙	🟢	Fo:20 Investment and expenditure in forest management	🟡	→	🟢
Fo:21 Value ($) of forest-derived ecosystem services	🟡	?	🟡	Fo:21 Value ($) of forest-derived ecosystem services	🟡	?	🟡

Victorian Government progress on State of the Environment 2018 Report recommendations

The SoE 2018 Report included recommendations to the Victorian Government to improve environmental sustainability outcomes. Presented below is the recommendation(s) specific to this theme as well as:

- The full Government response to the recommendation(s), including the level of support, as published in Victorian Government Response to the SoE 2018 Report.
- Progress made on the implementation of the recommendation(s) over the last five years. The content of this section is derived from written material supplied directly to the Commissioner for Environmental Sustainability by relevant government entities and/or synthesises information that is publicly available in referenced reports, legislation, and websites. Importantly, the intent of this section is to provide a summary on the progress made for the recommendation since 2018, rather than an audit of the extent and quality of the work that has been completed.

Recommendation 8 of the SoE 2018 Report recommended:

> *Recommendation 8: That DELWP maintain their commitment to resourcing and maintaining the VFMP and enhance it to (i) improve statewide understanding of the impacts of forest fragmentation on forest-dependent species (including the development of an authoritative list of Victorian forest-dependent species) and (ii) improve assessment of protected areas by conducting detailed research to identify the benefits of various types of International Union for Conservation of Nature (IUCN)-protected areas for target species. Any amendments to the VFMP must not disrupt future trend analyses.*

Government response in 2020:

SUPPORT

'The Victorian Government supports this recommendation.' [1238]

'The Victorian Forest Monitoring Program (VFMP) has been collecting information on the biophysical attributes and botanical diversity of Victoria's forests since 2011. The Government understands the benefits of the program accrue over time and is committed to the continuation of the program.' [1239]

'Botanical information from the program is delivered in the Victorian Biodiversity Atlas, which also now includes the authoritative list of Victoria's forest-dependent species. Data from the VFMP more broadly underpins a range of derived datasets and modelling processes and provides valuable ground truthing data used to verify satellite image analysis, including the assessment of forest fragmentation. Recent forest extent time-series data have been used to assess the status of fragmentation across time.' [1240]

'The program is specifically designed to differentiate forest health characteristics between state forests and conservation reserves, including national parks. The information generated through the program and its contribution to complementary scientific studies assists the Government in understanding the utility of the state's reserve system, and in doing so, the IUCN protected areas. In addition, the forest values assessment program currently being implemented through the forest management reform program, is undertaking a review of the Comprehensive, Adequate and Representative (CAR) reserve system, which is underpinned by the IUCN criteria.' [1241]

'Any amendments to the VFMP program will ensure the time-series data are complemented and enriched and will not undermine the legacy of information collected to date.

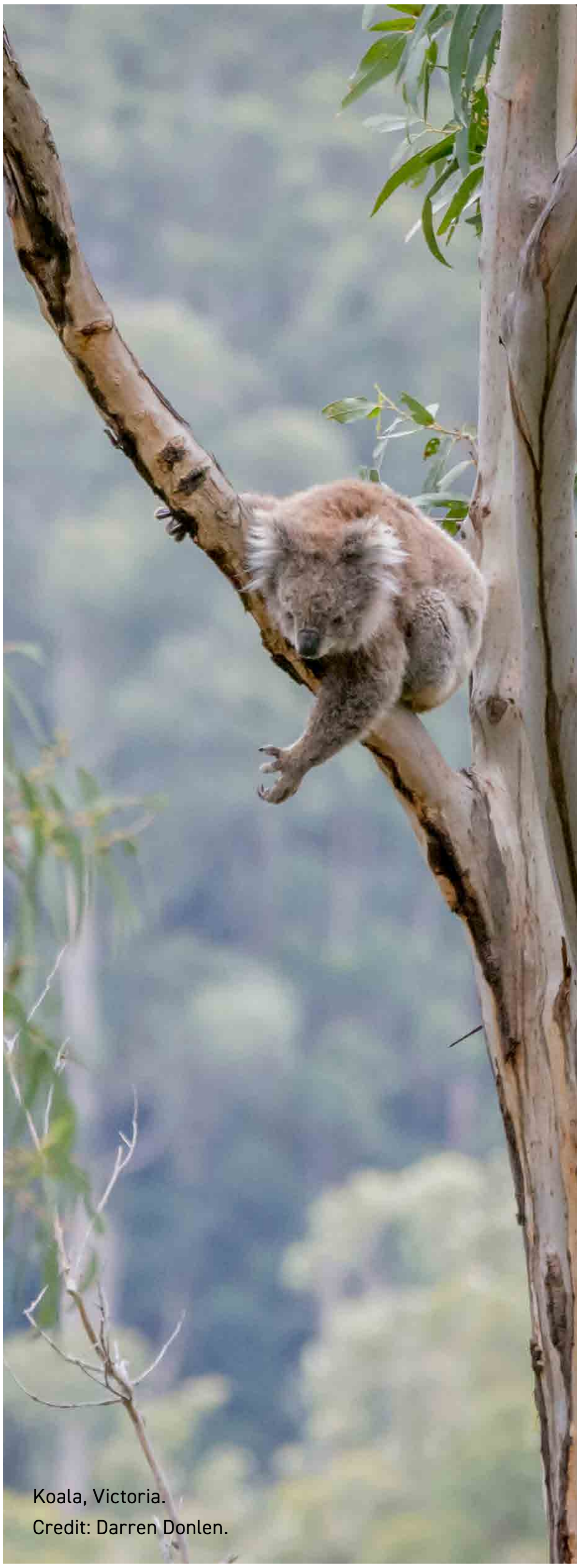
1238. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian Government response to the state of the environment 2018 report', Melbourne, Victoria, https://www.environment.vic.gov.au/__data/assets/pdf_file/0017/504008/Victorian-Government-response-to-the-State-of-the-Environment-2018-report.pdf. Accessed 16 March 2023.
1239. Ibid.
1240. Ibid.
1241. Ibid.

> At the same time, a process on continual improvement is applied through annual review. In the 2019/20 field season, additional metrics were included to strengthen assessment of vegetation condition; and for the first time, Traditional Owner groups were engaged for the dual benefit of enabling working on country opportunities and to advise on the development of cultural health indicators across public forests. Future enhancements may include integration of new remotely sensed imagery to assist long-term assessment of impacts associated with climate change and other disturbances.' [1242]
>
> 'Current and future data derived from the VFMP will contribute to Government initiatives aimed at understanding the effectiveness of the protected area estate in the conservation of target species and key forest values.' [1243]

Progress made since 2018

DEECA has commissioned population viability research undertaken by the University of Melbourne's School of Ecosystem and Forest Sciences. This research used spatially explicit population modelling to determine, describe and predict impacts of key drivers of forest fragmentation including timber harvesting, climate change, and bushfires on seven of Victoria's high priority forest-dependent threatened species. An additional project to further refine the process for two species, the Southern Greater Glider (*Petauroides volans*) and the Leadbeater's Possum (*Gymnobelideus leadbeateri*) is currently underway.

A review of the CAR reserve system of the five Victorian RFA regions was undertaken and focussed on the extent of ecological vegetation classes (EVCs) within the protected area system within these RFA regions. Several forest-dependent priority species and their distribution were modelled as part of this review. A more complete update is in development and will be provided after review by the Whole of Victorian Government Regional Forest Agreement Steering Committee.



Koala, Victoria.
Credit: Darren Donlen.

[1242] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian Government response to the state of the environment 2018 report', Melbourne, Victoria, https://www.environment.vic.gov.au/__data/assets/pdf_file/0017/504008/Victorian-Government-response-to-the-State-of-the-Environment-2018-report.pdf. Accessed 16 March 2023.

[1243] Ibid.

Forests

Background

Forests, and the services they provide, are essential for the health and wellbeing of all Victorians. Forests maintain Victoria's water quality, purify the air and store carbon, stabilise and nourish soil, assist agriculture, and support economies vital for regional communities and businesses. Forests are critical habitats for biodiversity, especially for the conservation of many iconic threatened species in Victoria. Forests have also been an essential part of the history and culture for Victoria's Traditional Owners and Aboriginal Victorians.

The definition of 'forest' used by Australia's National Forest Inventory, established in 1988, is:

> 'An area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding 2 metres and with existing or potential crown cover of overstorey strata about equal to or greater than 20%. This includes Australia's diverse native forests and plantations, regardless of age. It is also sufficiently broad to encompass areas of trees that are sometimes described as woodlands.' [1244]

This definition of forests also includes a minimum area of 0.2 hectares.

Public land in Victoria covers around 8 million hectares, which is approximately a third of the state.[1245] The majority of the public land is comprised of national parks and other conservation parks managed by Parks Victoria (PV; 4 million ha) and state forests managed by DEECA (3.2 million ha; Figure Fo1).[1246] Victorian forests are a mix of:

- box, ironbark and gun-barked eucalypts in central Victoria
- medium and tall damp sclerophyll forests across much of Victoria
- tall wet sclerophyll forests in the east of the state
- dry sclerophyll forests in the east, central and south-west of the state
- rainforests
- mallee forests in north-western Victoria.

Eucalypts dominate the forests and include red and brown stringybarks, narrow-leaved peppermint, messmate stringybark, mountain ash, alpine ash, and river red gum.

[1244] Department of Agriculture and Water Resources, 'Australia's forests', Canberra, Australian Capital Territory, http://www.agriculture.gov.au/abares/forestsaustralia/australias-forests Accessed 3 September 2022.

[1245] Department of Energy, Environment and Climate Action (DEECA) 'Managing crown land', Melbourne, Victoria, https://www.forestsandreserves.vic.gov.au/land-management/managing-crown-land Accessed 26 September 2022.

[1246] Ibid.

Forests

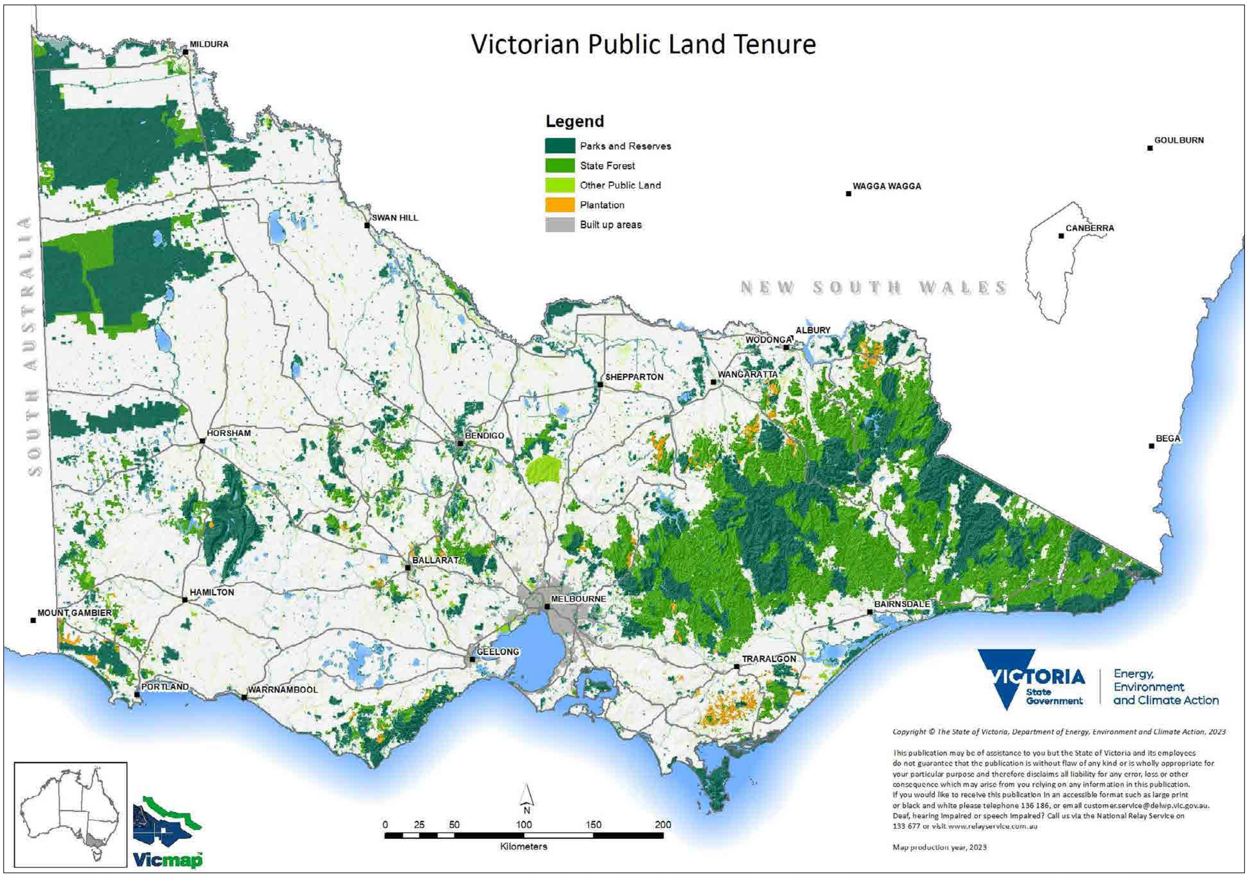


Figure Fo1: Victorian state forests and parks and reserves during 2023.[1247]

Since European settlement, more than 14 million hectares (60%) of Victorian land has been cleared, mainly for agriculture and settlements.[1248] This significant change coincides with the departure from traditional land management practices that were applied by Traditional Owners, including cultural burning. It resulted in significant ecological changes to Victoria's natural environment and increased risks to community.[1249] Victoria's population growth and subsequent urban expansion will increase the pressure on Victorian forests through elevated water demand from forest catchments and timber harvesting.[1250]

The Victorian SoE 2018 Report indicated that there were several major issues that the literature identified for long-term sustainable forest management in Victoria. These were climate change, changing fire regimes, deteriorating biodiversity, forest fragmentation, economy and the legal framework. Many of these issues have been worsened, making Victorian forests more vulnerable to achieve sustainable forest management. Climate change has been the main driver behind Australia having more regular and larger bushfires and blazes which cause greater forest destruction. This is likely to continue with considerable implications for sustainable forest management.[1251]

1247. Department of Energy, Environment and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.
1248. Commissioner for Environmental Sustainability (CES) 2013, 'State of the Environment report 2013', Melbourne, Victoria, https://www.ces.vic.gov.au/state-of-reports/state-environment-2013-report Accessed 3 December 2018.
1249. Victorian Traditional Owner Cultural Fire Knowledge Group 2018, 'The Victorian Traditional Owner cultural fire strategy'. https://knowledge.aidr.org.au/media/6817/fireplusstrategyplusfinal.pdf Accessed 25 November 2022.
1250. Lindenmayer DB, Sato C 2018, 'Hidden collapse is driven by fire and logging in a socioecological forest ecosystem'. Proceedings of the National Academy of Sciences, 115, pp. 5181-5186.
1251. Canadell JG, Meyer CP, Cook GD, Dowdy A, Briggs PR, Knauer J, Pepler A, Haverd V 2021, 'Multi-decadal increase of forest burned area in Australia is linked to climate change, *Nature Communications*, 12, pp. 6921, https://doi.org/10.1038/s41467-021-27225-4 Accessed 3 October 2022.

Forests

As a result of the 2019–20 bushfires, around 10% of vegetation (758,056 ha) at state scale was burnt on public land in 2019-20 while it was still below minimum tolerable fire interval (TFI) (Figure Fi5). This is by far the greatest extent burnt while the ecosystem was below minimum TFI since 1980. This means that such areas have an increased likelihood of the vegetation undergoing a long-term, and potentially, irreversible change in its composition and structure (e.g. alpine ash forest being replaced by acacia thickets).[1252] In the rapidly changing climate trend, water yield estimation is becoming more difficult as the impacts of high-frequency, high-severity fires on mixed species are currently unknown as this worsening fire regime could trigger species transition.[1253] Additional issues identified over the last five years include:

- Data deficiency in biodiversity: Assessment to determine a species' status can vary in accuracy and reliability due to data gaps and limited expert knowledge for some species.[1254] This is mainly because agencies prioritise their focus on arresting the decline of selected species and communities leading to reliance on expert knowledge of the species which, at times, does not exist or is not current. In addition, 21 species listed under the *Flora and Fauna Guarantee Act 1988* (FFG Act) as critically endangered were identified to have critical knowledge gaps.[1255]
- Deteriorating trend in old-growth forest extent: Old growth forests are significantly important in the maintenance of biodiversity and ecological functions, such as water and nutrient cycles. About 60% of modelled extent of old growth forest have been lost, predominantly due to severe bushfires since 2000.[1256] The intensifying trend in fire intensity and frequency due to climate change means that there is a higher chance that the loss of its modelled extent could be accelerated.

The Montreal Process

Australia is one of 12 member countries in the Montreal Process, which is an initiative that arose from a resolution at the 1992 Earth Summit calling for sustainable management of forests. The Montreal Process is a voluntary agreement between nations to monitor and report on agreed criteria and indicators for the conservation and sustainable management of forests. Australia has accepted the criteria and developed indicators that best represent Australia's unique forest conditions under the *Framework of Regional (Sub-National) Level Criteria and Indicators of Sustainable Forest Management in Australia* (the framework).

Victoria has developed 45 indicators for reporting on the state's forest management under the framework.[1257] Since 2003, the Department of Environment, Land, Water and Planning (DELWP) has produced three iterations of Victoria's State of the Forest (SoF) report every five years to ensure accurate and consistent performance reporting against the criteria. To increase the independence of the report's findings, the Commissioner for Environmental Sustainability prepared and issued the 2018 SoF report. Through the reporting process, a range of key challenges have been identified that are necessary to achieve sustainable forest management. Through discussions with relevant stakeholders, the Commissioner for Environmental Sustainability has selected 21 indicators from six criteria relevant for the Montreal Process to be discussed in this chapter.

Victorian Forest Monitoring Program

DELWP's VFMP was established in 2011. It measures and monitors landscape-level trends in forest ecosystems in the Victorian public land estate and is one of few broadscale forest-monitoring processes operating in Australia.[1258] It aims to provide relevant information for the Montreal Process and contribute to policy development and decision-making related to carbon, biomass and ecosystem-service accounting, water yield modelling, habitat structure, forest health and productivity, and the impacts of disturbances, such as fire.

1252. McColl-Gausden SC, Bennett L, Ababei DA, Clarke HG, Penman TD 2022, 'Future fire regimes increase risks to obligate-seeder forests', *Diversity and Distributions*, 28, pp. 542–558, https://doi.org/10.1111/ddi.13417 Accessed 28 October 2022.
1253. Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.
1254. Victorian Auditor General's Office (VAGO) 2021, 'Protecting Victoria's Biodiversity', Melbourne, Victoria, https://www.audit.vic.gov.au/report/protecting-victorias-biodiversity?section= Accessed 3 October 2022.
1255. Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.
1256. Ibid.
1257. Department of Sustainability and Environment (DSE) 2007, 'Criteria and indicators for sustainable forest management in Victoria: guidance document', Melbourne, Victoria, https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0022/30865/Vic_Indicators_for_SFM_Guidance.pdf Accessed 3 October2022.
1258. Haywood A, Thrum K, Mellor A, Stone C 2017, 'Monitoring Victoria's public forests: implementation of the Victorian Forest Monitoring Program', *Southern Forests*, 2620, pp. 1–10.

Forests

The VFMP comprises a network of 803 permanent ground plots which are grouped into 21 distinct strata according to Victoria's 11 bioregions and public land tenure (Table Fo2).[1259] The field measurement process has now achieved 89% (717 plots) of the 803 ground plots, with the remaining plots not measured due to various constraints, such as accessibility or other hazards (e.g. Covid-19 restrictions and damage caused by 2019-20 bushfires). Within the 2011-16 measurement cycle, 97% of plots (639 out of 662) were visited to collect field information whereas during the 71% (509 out of 717) were visited during the 2016-21 cycle. Locations of the sampling units for VFMP is shown in Figure Fo2 while the results of the VFMP's first two measurement cycles (2011-16 and 2016-21) are reported within the indicator assessments, enabling limited trend analysis in some circumstances.

It is important to note that comparisons between the results presented in this report and previous reports is limited due to changes to data collection and improvements in data quality. For example, in 2013 only 337 plots (or approximately 40%) had been measured (Table Fo2). While important, increased sample sizes and improved accuracy have introduced analytical 'noise'. More accurate trend analysis for all VFMP metrics will be possible as larger sample sizes are obtained.

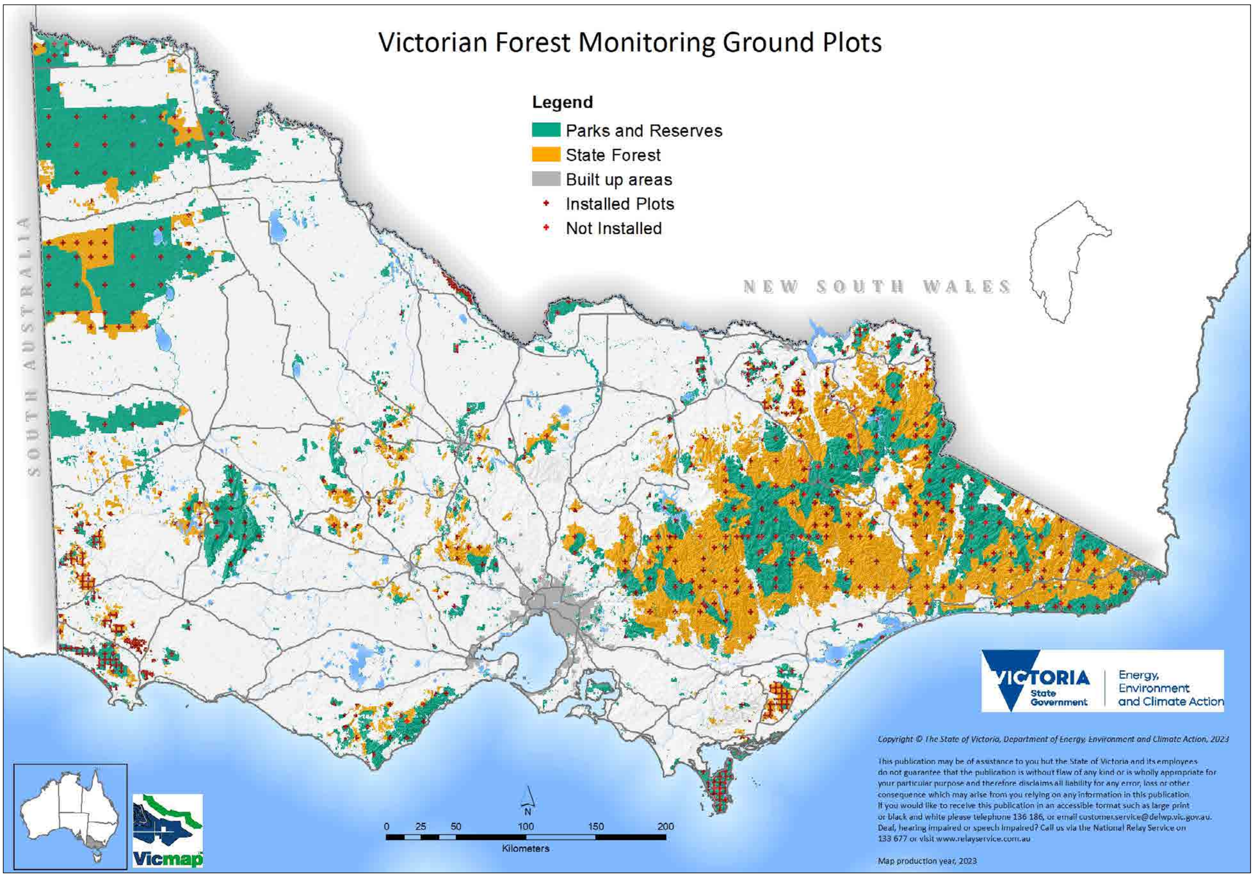


Figure Fo2: Location of sample points for the VFMP in 2023.[1260]

[1259] Australian Department of the Environment and Energy, 'Australia's bioregions (IBRA)', Canberra, Australian Capital Territory, http://www.environment.gov.au/land/nrs/science/ibra Accessed 3 December 2018.

[1260] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Table Fo2: Number of VFMP plots installed by bioregion in 2013, 2018 and 2022.[1261]

Bioregion	2013	2018	2022
Australian Alps	61	76	81
Furneaux (Flinders)	9	19	20
Murray-Darling Depression	21	58	63
Naracoorte Coastal Plain	32	79	83
NSW South Western Slopes	27	65	73
Riverina	27	69	62
South East Coastal Plain	24	40	47
South East Corner	29	66	74
South Eastern Highlands	50	74	80
Victorian Midlands	36	66	76
Victorian Volcanic Plain	21	50	58
Total number of VFMP plots	337	662	717

Policy and legislative settings

Victoria's forests are managed in accordance with Victorian legislation, including the *National Parks Act 1975, Forests Act 1958, Conservation, Forests and Land Act 1987, Flora and Fauna Guarantee Act 1988, Crown Land (Reserves) Act 1978, Land Act 1958* and the *Sustainable Forests (Timber) Act 2004*, along with related regulations, codes of practice, management plans and policy initiatives.

In 2017, the VEAC recommended that, within five years, state forests should be administered under one act. It also recommended a new public land act to replace the current Land Act, Crown Land Act and Forests Act.[1262] The Victorian Government accepted both recommendations. However, the Victorian Government has still not completed legislation to consolidate these three Acts into a new Public Land Act, although consultation was completed in 2021. An engagement report summarising the feedback received was released later that year prior to finalising the policy to guide the development of the new legislation. At the same time, it will refine the Victorian *National Parks Act*, which will operate alongside the new Public Land Act once it is put into effect.

The Forests Act is used to support the management and use of Victoria's state forests and includes provisions for firewood collection, fire management, forest park establishment and licensing of various uses such as grazing.

The objective of the Conservation, Forests and Lands Act is 'to be an effective conserver of the state's lands, waters, flora and fauna; and to make provision for the productive, educational and recreational use of the state's lands, waters, flora and fauna in ways which are environmentally sound, socially just and economically efficient.'[1263] It details administrative arrangements, powers and functions and includes provisions for codes of practice, land management cooperative agreements, Traditional Owner land management boards and joint management plans.

The *Sustainable Forests Act* includes provisions for the allocation of timber to VicForests through issuance of an Allocation Order, compliance with the Code of Practice for Timber Production, the preparation and implementation of the TRP, and the framework for SoF reporting.

1261. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.
1262. Victorian Environmental Assessment Council (VEAC) 2017, 'Statewide assessment of public land, final report', Melbourne, Victoria, https://www.veac.vic.gov.au/investigations-assessments/previous-investigations/investigation/statewide-assessment-of-public-land Accessed 20 April 2023.
1263. State Government of Victoria 1987, '*Conservation, Forests and Lands Act 1987*', Melbourne, Victoria.

Forests

The VFP was released by the Victorian Government in November 2019.[1264] It outlines the policy directions for Victorian forest industries and the management of timber resources in state forests. The plan includes the phasing out of all public native forest harvesting by 2030. This means that plantation areas in Victoria would need to be expanded significantly to meet a growing demand. Victoria pledged $110 million in the 2017–18 State Budget as part of the Timber Plantation Establishment initiative for the Gippsland Plantations Investment Program, a component of the VFP, to encourage further investment by the private sector in the establishment of new plantations in Gippsland that would act towards increasing Victoria's future plantation wood supply.[1265] In early 2022, the Commonwealth Government announced $86 million for a grants program to establish new soft and hard wood plantations in 11 declared, regional forest hubs — including green triangle, Gippsland and Murray region in Victoria. In 2023, an announcement was made on 23 May 2023 where the timeline for Victoria's native timber transition was revised, with the end of native timber harvesting being changed from 2030 to 1 January 2024.[1266]

While the VFP assists the timber industry's transition from native forest harvesting to a plantation-based timber supply, the Victorian Government also gave immediate protection from timber harvesting to 90,000 hectares of old-growth forests and released the Greater Glider Action Statement which was supported by a further 96,000 hectares of state forests exempted from timber harvesting by the establishment of Immediate Protection Areas (IPAs).[1267]

The purpose of the Code of Practice for Timber Production 2014 is to provide direction to timber harvesting managers, harvesting entities and operators for the delivery of sound environmental performance when planning for, and conducting, commercial timber harvesting operations in a way that:

- permits an economically viable, internationally competitive, sustainable timber industry
- is compatible with the conservation of the wide range of environmental, social and cultural values associated with forests
- provides for the ecologically sustainable management of native forests proposed for cyclical timber harvesting operations
- enhances public confidence in the management of timber production in Victoria's forests and plantations.[1268]

In Victoria, 20 mammal, 14 birds, 6 reptiles, 6 amphibians, 14 fish, 10 crustaceans, 2 terrestrial invertebrate species and 315 plant species are protected by 'prescriptions' that attempt to mitigate timber harvesting impacts under the code.[1269]

When revising Victoria's RFAs in 2019, the Commonwealth and Victorian governments said that they are a 'means of balancing environmental, economic and social uses and values of key native forest regions across Australia.' [1270, 1271]

The VFMP was established in 2011 'to provide baseline data for long term trend detection and prediction of type and severity of future changes, so that management options can be developed and evaluated in time to be effective'.[1272] It provides a platform to meet statutory reporting obligations, support forest policy and management decisions and assess Victoria's performance towards sustainable forest management.' [1273] The program has more than 600 monitoring sites across Victoria's forested bioregions. Although approximately 90 were burnt by the 2019–20 bushfires, they continue to be monitored.

The TRP identifies the forestry coupes that are available for timber harvesting in the future.[1274] The coupes are found within a larger area covered by the Allocation Order, which is released by the Minister for Agriculture and gives VicForests access to state forests. The Timber Utilisation Plan applies to areas outside the boundary defined in the Allocation Order and which are largely in the Western RFA.[1275]

[1264] Department of Jobs, Precincts and Regions (DJPR) 2019, 'Victorian forestry plan 2019', Melbourne, Victoria, https://djpr.vic.gov.au/forestry/forestry-plan Accessed 9 May 2021.

[1265] Department of Treasury and Finance (DTF) 2017, 'Getting on with the job: Victorian Budget 17/18 overview'. Melbourne, Victoria https://www.dtf.vic.gov.au/sites/default/files/2018-02/state-budget-overview-2017-18.pdf Accessed 4 December 2018.

[1266] Premier of Victoria, 'Delivering certainty for timber workers', Melbourne, Victoria, https://www.premier.vic.gov.au/delivering-certainty-timber-workers Accessed 24 May 2023.

[1267] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Action statement No. 267 greatergGlider (Petauroides volans subsp. volans)', Melbourne, Victoria.

[1268] Department of Environment and Primary Industries (DEPI) 2014, 'Code of Practice for Timber Production 2014', Melbourne, Victoria.

[1269] State Government of Victoria, 'Forest protection survey program', https://www.vic.gov.au/forest-protection-survey-program Accessed 19 April 2023.

[1270] State of Victoria, Commonwealth of Australia 2019, 'Victoria's Regional Forest Agreements: Assessment of matters pertaining to the modernisation of Victoria's Regional Forest Agreements', Australia.

[1271] Ibid.

[1272] State Government of Victoria, 'Victorian forest monitoring program' Melbourne, Victoria, https://www.forestsandreserves.vic.gov.au/forest-management/victorian-forest-monitoring-program Accessed 9 May 2021.

[1273] Ibid.

[1274] VicForests, 'Timber release plan', Melbourne, Victoria, https://www.vicforests.com.au/planning-1/timber-release-plan-1/approved-timber-release-plan Accessed 9 May 2021.

[1275] Ibid.

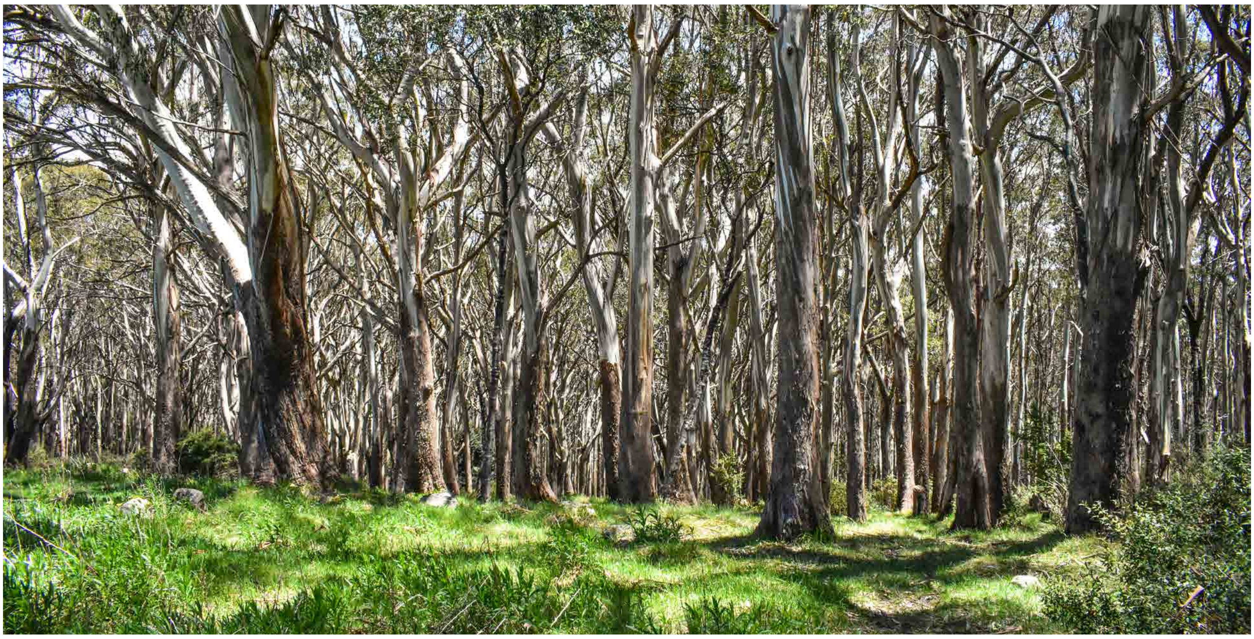
Forests

Forest management plans (FMPs) were developed in the 1990s and early 2000s and divides Victoria's forests into zones and establishes objectives for conservation, land management and uses that include timber harvesting.[1276] A modernisation of Victoria's RFAs include a commitment to review FMPs by December 2023 and at least every 10 years thereafter, for so long as the agreements remain in effect (Clause 65(b) in Central Highland RFA). There are eight plans covering forest management areas in the state that include East Gippsland, the Central Highlands, the North East and Midlands. The plans identify the location of three forest management zones:

- General management zone (GMZ): managed for a range of uses, with timber production having a high priority
- Special management zone (SMZ): managed to conserve specific features and where timber production is catered for under certain conditions
- Special protection zone (SPZ): managed for conservation and where timber harvesting is excluded. Planned burning and grazing may be allowed if compatible with maintaining the area's values.

The Statewide Protection for Large Trees Policy 2019 requires that, in all coupes where timber harvesting is conducted, VicForests must retain and protect all large trees from the direct impacts of timber harvesting and regeneration burning, including by ensuring that slash and bark accumulation is cleared from within three metres of the base of retained trees. The content of this policy was codified in the Code of Practice for Timber Production through amendments made in 2021.

The Forest Protection Survey Program aims to identify and protect animals and plants that are either threatened or of high conservation value where they occur in areas (or coupes) of state forests scheduled for harvesting.[1277] This survey work is taking place in state forests in Gippsland, the Central Highlands and North-East regions of eastern Victoria. This means that the program does not cover areas in western Victoria where community forestry occurs at small scale. The aim of the program is to survey at least 80% of coupes planned for harvest each year covered by the Allocation Order. VicForests is also required to undertake its own assessment of biodiversity values on coupes prior to harvesting.



Yarra Ranges National Park.
Credit: LOTE Marketing. © Parks Victoria.

[1276] Department of Environment, Land, Water and Planning (DELWP), 'Forest management plans', Melbourne, Victoria, https://www.forestsandreserves.vic.gov.au/forest-management/forest-management-plans Accessed 9 May 2021.

[1277] Department of Energy, Environment and Climate Action (DEECA), 'Forest protection survey program', https://www.vic.gov.au/forest-protection-survey-program Accessed 19 April 2023.

Forests

Indicator Assessments

Refer to ‘Guide to the indicator assessments’ at the start of Part 3 for the accompanying definitions and legends related to the indicator assessment summary tables.

Ecosystem diversity

Maintenance of the variety and quality of forest ecosystems is necessary for the conservation of biodiversity. This is a key element of ecologically sustainable development. Without understanding the current status and trend of various relevant aspect, including adequate connectivity, appropriate protection and management measures, and structural diversity, forest-dependent species may decline and become vulnerable to extinction.

Indicators in this sub-theme provides information on the area and extent of forest ecosystem types including successional stage, age class, the nature of tenure or ownership, and protections and fragmentation status of Victorian forests.

Indicator Fo:01A Area of forest by type and tenure - forest canopy cover

Fo:01A Area of forest by type and tenure – forest canopy cover

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	?	🔴	●	?	🔴
Data source(s):	DELWP					
Measure(s):	Forest canopy cover					

Why this indicator?

Canopy cover protects the ground from the force of rainfall, and moderates the force of wind. It acts as an indicator of factors including nutrition, water access, disease, pest infestations and stress. The impact of forest use, in terms of deforestation, degradation, thinning or afforestation, can also be evaluated by canopy cover.

Why this assessment in 2023?

There is insufficient information to assess this indicator.

Summary of State of the Environment 2018 Report assessment

- Canopy cover is one in a set of important parameters that describe structural forest conditions. However, it is not sensitive to many structural attributes such as tree age, size and density. This can be used as a set of key indicators or variables to evaluate whether forest structure is within the natural range of variability and in turn whether forests are approaching desired conditions.
- With the limitation in any analysis of forest structure using canopy cover, it was difficult to assess a status. In the 2018 report, there was a single year snapshot of canopy cover information with the description of accuracy in the canopy cover analysis, which resulted in the trend ‘unclear’.

Critical data used for the 2023 assessment

- New data were unavailable for this indicator

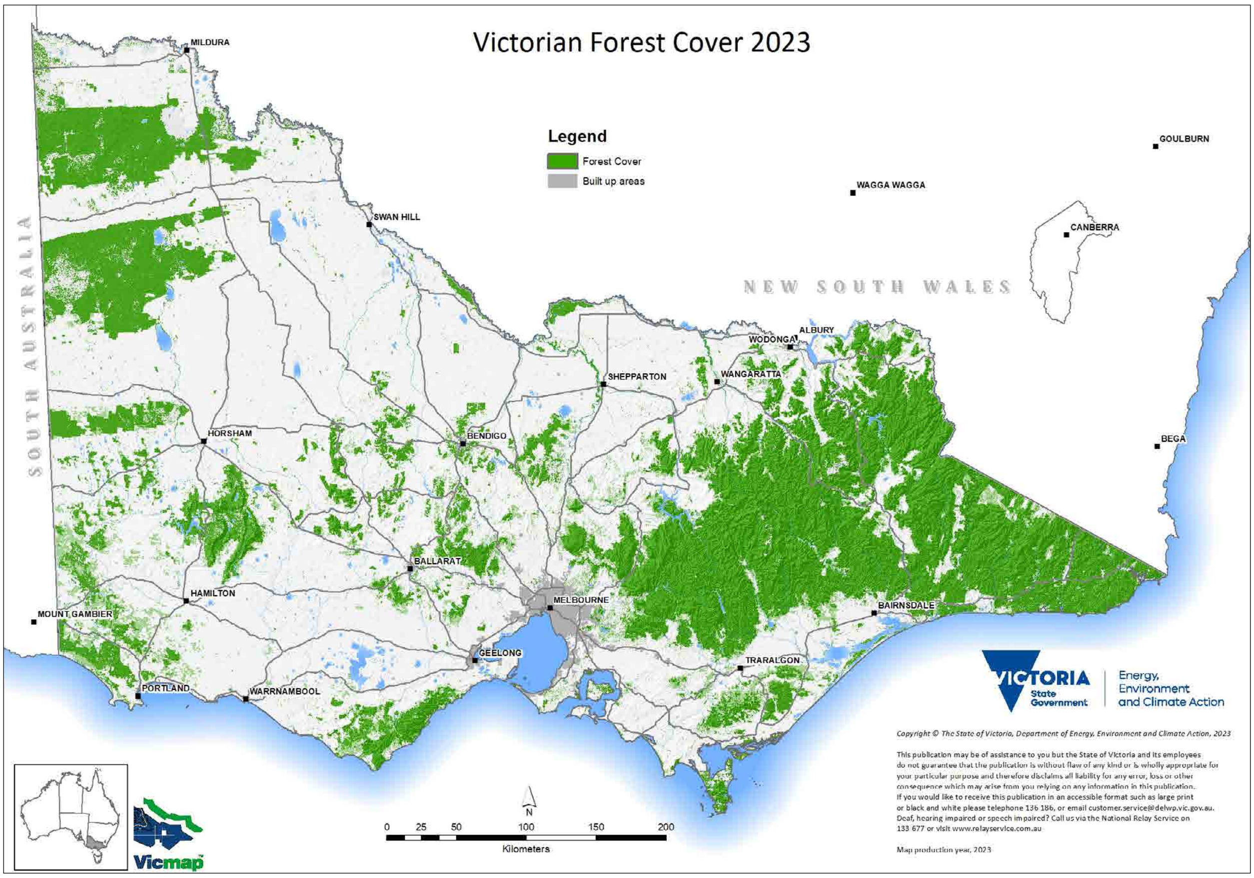
Forests

2023 assessment

To effectively manage Victorian forests, it is necessary to understand forest area by type, as it provides a broad measure of forest ecosystem and biodiversity maintenance. Changes in forest area and structure over time also provide an indicator for the impact of environmental disturbances and extreme events (e.g. bushfires) on forest ecosystems.

Forest canopy cover information is an essential element for forest monitoring. The canopy cover acts as an indicator of the health of forest such as nutrition, water access, disease, pest infestations and stress. In addition, this is also used to study the effects of fire and microclimate.

Due to the unavailability of a comprehensive and accurate canopy cover dataset, similar to the previous state of environment reporting period, the forest extent map of Victoria is used as an indication of canopy cover (Figure Fo3). However, no interpretation of the map was provided.



Map production year, 2023

Figure Fo3: Forest extent in Victoria during 2023.[1278]

[1278] Department of Energy, Environment and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.

Forests

Indicator Fo:01B Area of forest by type and tenure - forest type

Fo:01B Area of forest by type and tenure – forest type

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	?	🔴	🟡	↗	🟢
Data source(s):	DELWP					
Measure(s):	Change in forest area by broad forest type and impact of natural disturbances, such as bushfire Height and canopy cover in state forests, and parks and reserves					

Why this indicator?

This indicator measures the current level of forest and canopy cover by broad forest type. It demonstrates how the forested area is changing over time. This knowledge is fundamental for the effective management of Victoria's forests.

Why this assessment in 2023?

There is no comparative measure to determine the current status of forest by type and tenure in Victoria. Previous information from the SoE 2018 Report cannot be assessed against the 2022 data due to methodological changes as well as changes in spatial data resolution. This highlights an urgent need for a systematic approach in achieving a long-term monitoring system for sustainable forest management. Trend analysis could not be performed due to a lack of data, as there is no time series data on forest extent by type and tenure. The only meaningful information for this indicator was information on findings about old-growth forest extent.

Summary of State of the Environment 2018 Report assessment

- The area of most forest types has increased. A notable exception is the 'forest unclassified (burnt)' type which increased dramatically after the February 2009 'Black Saturday' fires but has decreased as forest areas recovered.

Critical data used for the 2023 assessment

- Major Event Review of the 2019-20 Bushfires
- Area of forest by broad forest type for state forests and parks and conservation reserves

2023 assessment

Forest is defined by the National Forestry Index (NFI) as an area greater than 0.5 hectares of native forest, with a dominant vegetation height of greater than 2 m and canopy cover greater than 20%. Land areas that fall under this definition are assigned a land-cover classification based on their species, dominant height and canopy cover, as well as the level of disturbance the area has received. Forest types are based on the relative abundance of eucalypt species (eucalypt, mallee or mixed) and divided into the height classes as low (2–10 m), medium (11–30 m) and tall (>30 m).

The data used for assessing area by forest type differed between the SoE 2018 and 2023 reports. The statewide data used to derive forest type information for the SoE 2018 Report was comprised of high and moderate resolution remote sensing (digital aerial photography and Landsat Thematic Mapper) data that had a resolution of 30 x 30 m. Machine learning technology was applied to classify land cover with a field validation program (VFMP). A variety of input data, including topography, climate and vegetation indices, were incorporated to produce a forest/non-forest layer that could be used to detect land-cover changes through time.[1279] In having a dataset with two-time stamps of remotely sensed data, trend analysis was possible. However, for the SoE 2023

[1279] Mellor A, Haywood A 2010, 'Remote sensing Victoria's public land forests – A two tiered synoptic approach', 15th Australian Remote Sensing and Photogrammetry Conference, Alice Springs, Northern Territory, Australia, 13-17 September 2010, https://www.researchgate.net/publication/265382020_Remote_Sensing_Victoria's_Public_Land_Forests_-_A_Two_Tiered_Synoptic_Approach Accessed 19 December 2022.

Report, the data provided by DELWP was for only a single year of forest type information and was at a different resolution (100 x 100 m resolution). In addition, a different mechanism to develop forest extent was used to process the remotely sensed data. Together, this made the data between the two state of environment reports incomparable and thus prevented a status and trend assessment to be conducted for this SoE Report. For such assessments of environmental values to be meaningful, long-term time-series data with spatial analyses is required.

Table Fo3: Area of forest by broad forest type within Victorian state forests and parks and conservation reserves in 2022.[1280]

Forest type	Cover	State forest	Parks and conservation reserves
Eucalypt	Low Woodland	2,308	6,138
	Medium Open	1,907,871	1,116,268
	Medium Woodland	356,688	645,926
	Tall Open	522,600	300,462
Mallee eucalypt	Open	45,792	250,970
	Woodland	153,978	789,832
Mixed	Acacia	14,116	17,556
	Callitris	1,142	16,576
	Casuarina	5,773	34,823
	Melaleuca	5,303	14,019
	Mangrove	-	768
	Rainforest	14,313	18,140
Non-forest	Non-forest	91,719	606,588
Other forest - unallocated type	Other forest - unallocated type	1,652	901
Other native forest	Other native forest	67,003	231,196
Plantation	Plantation	2,672	1,058

The data challenges to assess this indicator highlights the lack of continuity of achieving high-quality monitoring efforts in Victoria. A systematic approach to understanding the state and future trends of Victorian public forests is critical. Only long-term time-series monitoring at the state scale can achieve this. Furthermore, some findings from the long-term data could be contrary to expectations and can result in stimulating new directions for forest research and management.

Old growth forest

Old growth forest is one of the critical forest types that holds significant environmental values. It is important in the maintenance of biodiversity (fauna, flora and insect diversity) and ecological functions (nutrient and water cycles).

The Independent Panel of the Major Event Review of 2019-20 Bushfires used publicly available information of modelled extent of old growth forest and fire severity datasets to estimate the impact of the fires on old growth forest extent in Victoria. Although this surrogate analysis could be limited by uncertainty in the data informing the analysis, which carries known limitations as modelled-only data, it does show how its extent has been decreasing over the last 18 years from 851,202 to 344,110 hectares. This reduction occurred when an area was exposed to high-severity fires. The projection of more frequent severe and large fires in the future due to climate change makes the remnant extent more vulnerable.

The review also indicated that the current approach to protecting the old growth forest in Victoria primarily focuses on protecting the remnant extent from timber harvesting. The Victorian Government acknowledges that the modelled extent does not

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[1280] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

represent the true extent of the old growth forest in Victoria. Therefore, there are protection mechanism through field survey programs, including CR's old growth forest identification tool, Forest Protection Survey Program and VicForests' survey of coupes, to identify old growth forests. Once old growth forests are identified, VicForests will apply protection measures and exclude from timber harvesting. However, these programs focus on areas where timber harvesting is scheduled. Considering the reduction of the old growth forest extent due to timber harvesting was only 7 hectares, this might indicate the current approach may be working. But, if the government only prioritises protecting its extent from timber harvesting, old growth forest extent will be much rarer and patchier and eventually disappear. Therefore, the Panel recommended that a mix of existing and innovative fire management practices be implemented that specifically focus on reducing bushfire risks to priority areas of old growth forests (Recommendation 8i).

When high severity fire impacts on old growth forests, they are no longer considered to be old growth. This leaves the old growth forest areas vulnerable to timber harvesting following high severity fires, even if values on the ground remain and fire severity was less than modelling showed. This is an important implication to mixed species forests as they typically can survive from high severity fires. The Panel found that around 1,013 hectares of modelled old growth forests impacted by 2019-20 bushfires in Victoria could be exposed to timber harvesting as included within TRP. The Panel recommended the Victorian Government to publicly release field verification results for those areas (Recommendation 8ii).

Woowookarung Regional Park 2015.
Credit: Peter Kervarec. © Parks Victoria.

Forests

Indicator Fo:01C Area of forest by type and tenure - plantation forest

Fo:01C Area of forest by type and tenure – plantation forest

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴	↙	🟡	🟡	→	🟢

Data source(s):	ABS
Measure(s):	Plantation area (ha) New plantation establishment per year Capacity to meet the demand for wood products

Why this indicator?

Information on the area of existing plantations and the trend in plantation establishment in private areas is important because Victoria is phasing out native timber harvesting by 1 January 2024. This means that Victoria will only be able to supply wood products from plantation forests or other jurisdictions.

Why this assessment in 2023?

There has been minimal new plantation establishment since 2012–13. Plantation area in Victoria for softwood has been stable, while the demand for wood products in Australia is growing, leading to an increasing reliance on imported sawnwood. Meanwhile, export of sawlogs is growing. The Victorian and Commonwealth governments have funded the establishment of new plantation areas in Victoria, but this is not reflected by the data yet, suggesting these may still be at the planning stage.

Total area of plantations has been decreasing since 2013–14, with a steep decline between 2018–19 and 2020–21. New plantation establishment has been minimal for almost a decade.

There is sufficient information on the plantation areas and change in new establishment of plantations in Victoria. The Victorian Forestry Plan (VFP) was developed after the SoE 2018 Report was released, so more information is required to assess this indicator. Reports regarding supply and demand dynamics for the Australian timber industry are available, but a Victorian context is missing. The Victorian Government's announcement to bring forward the end of native timber harvesting by 1 January 2024 may result in increased demand for timber from overseas, as there has been no sign of an increase of plantation areas in Victoria.

Summary of State of the Environment 2018 Report assessment

- The most recent statistics (2015-16) show Victoria has the largest total area of plantations in Australia.[1281] Victorian plantations account for approximately one-fifth of Australia's total plantation forest estate.
- Each year, plantation areas are harvested extensively, and some are not replanted and possibly left fallow. Since the 2010–11 financial year, plantation areas have gradually decreased by approximately 11,200 hectares. This is due to a decrease in the rate of new plantation establishments since 2000.
- In 2016–17, there were 421,700 hectares of industrial hardwood and softwood plantations in Victoria. Over the past 18 years, commercial softwood plantation areas have been stable at between 212,000 and 226,000 hectares. By contrast, commercial hardwood plantation areas doubled in the 10 years since the 1999–2000 financial year, from 101,500 to 203,000 hectares. This increase was mainly due to managed investment schemes, popular in the early 2000s. Several high-profile agri-business managed investment schemes collapsed, resulting in substantial losses for many investors.
- Newly established plantation areas in Victoria have decreased sharply from a peak of approximately 38,000 hectares in 1999–2000. No new plantation areas have been established since the 2012–13 financial year.

[1281] Australian Department of Agriculture and Water Resources (ABARES), 'Australian plantation statistics 2017 update', Canberra, Australian Capital Territory, https://data.gov.au/dataset/pb_aplnsd9abfe20170503/resource/477323a0-11dd-4276-a765-dc8e19fdeb49 Accessed 1 August 2023.

Critical data used for the 2023 assessment

- Plantation areas in Victoria by year
- New plantation establishment
- Wood supply and demand analysis at national scale

2023 assessment

Victoria's plantation forests provide export and domestic timber products, including both hard and softwood.[1282] Since plantation is a term for land use, both planted and fallow land may be referred to as plantations. Plantation forests are almost all privately owned (99%).

In 2020–21, with 381,912 hectares of industrial hardwood and softwood plantations, Victoria continued to have the largest total area of plantations in Australia.[1283] Victorian plantations contribute approximately one-fifth of Australia's total plantation forest estate. Each year, plantation areas are harvested extensively with some not being replanted and possibly left fallow.

Over the last 21 years, commercial softwood plantation areas have been stable: between 212,000 and 226,000 hectares. On the other hand, commercial hardwood plantation areas fluctuated significantly (Figure Fo4). The commercial hardwood plantation areas doubled within the 10 years from the 1999–2000 financial year, from 101,500 hectares to 203,000 hectares (Figure Fo3). This resulted in an increase of plantation areas in Victoria. This increase in commercial hardwood plantation areas was a result of the managed investment schemes of the early 2000s and resulted in substantial financial losses for investors. Several high-profile agribusiness-managed investment schemes collapsed. By the 2010–11 financial year, plantation areas had gradually decreased by approximately 11,200 hectares by 2016-17 as a result of decreasing rates of new plantation establishments since 2000. From 2019-20, a large drop of hardwood plantation area occurred. This is partially due to the 2019-20 bushfires which resulted in a loss of 901 hectares in eastern Victoria (7,453 hectares loss for softwood plantations).[1284] At state scale, around 9,800 hectares of plantation area in Victoria were within the 2019-20 bushfire extent.[1285]

In response to the impact of the 2019-20 bushfires, the Department of Jobs, Precincts and Regions (DJPR) funded the North East Plantation Bushfire Affected Timber Salvage Program in 2020 which assisted the plantation forest industries to maximise the salvage of fire-affected plantation timber before it became unmerchantable. This was an industry-wide program that covered fire-related costs borne by harvest and haulage contractors, wood processors and the plantation owners. Concentrating harvesting operations into the burnt plantations, and reducing harvesting of unburnt plantations elsewhere, further reduces losses from fungal decay of the merchantable burnt timber and saves timber in the unburnt plantations that would otherwise have been harvested for utilisation in future years.

the Australian Government also provided $40 million to the Forestry Recovery Development Fund following the 2019–20 bushfires which provided grants of between $1 million and $5 million to privately owned processors that faced long-term reductions in log supply. Four wood processors that utilise wood from Victorian plantations received a total of $10.3 million of funding from this fund.

1282. Note that in this SoE 2023 Report, the term plantation describes land use which includes both planted and fallow land.
1283. Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2018, 'Australian plantation statistics 2017 update', Canberra, Australian Capital Territory, https://data.gov.au/dataset/pb_aplnsd9abfe20170503/resource/477323a0-11dd-4276-a765-dc8e19fdeb49 Accessed 19 April 2023.
1284. Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.
1285. Department of Agriculture, Water and the Environment (DAWE) 2020, 'Australian plantation statistics 2020 update', Canberra, Australian Capital Territory, https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1030441/0 Accessed 1 December 2022.

The Independent Panel for reviewing the impact of 2019-20 bushfires on Victoria's RFAs found that:

> 'In the Gippsland bushfire management strategy, many of the private plantations located around the Tubbut, Bonang, Bendoc and Coast Range, areas do not appear to be given adequate fuel management protection via bushfire moderation zones. The situation in the Hume bushfire management strategy is less clear, as the plantations are more dispersed across the region and the interactive website does not directly compare plantation areas and the fuel management zones. Nevertheless, there appears to be a lot of landscape management zone in proximity to many of the plantation areas, which would mean that they are not necessarily given a high level of priority for protection.' [1286]

Protection of plantations through the land management zone will also mean that more fire applied to native forests on public land will in many cases result in the decline in ecosystems and species. Recommendations have been developed based on the findings that the Victorian and Commonwealth governments should consider giving a high-level of priority for protection of plantations from bushfire in their policy arrangements.

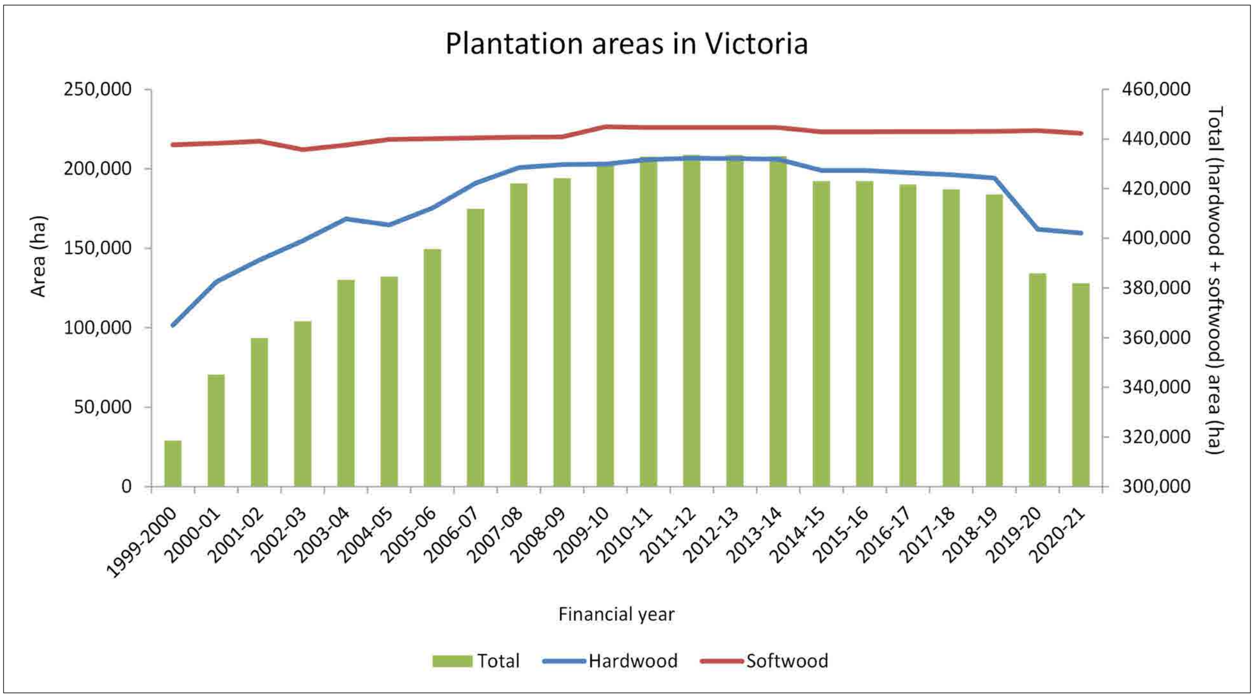


Figure Fo4: Plantation areas in Victoria from 1999–2000 to 2020–21.[1287]

[1286] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

[1287] Commonwealth of Australia 2020, 'Data tables - Australian forest and wood products statistics: Sep - Dec quarters 2021', Canberra, Australian Capital Territory, https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1033683/3 Accessed 29 June 2022.

The volume of softwood logs harvested in Victoria fluctuated significantly between 2002-03 and 2020-21 (Figure Fo5). Since 2002-03 production of softwood logs dramatically increased by 2016-17 and then declined by 2020-21. This is mainly due to the imposition of trade restrictions negatively affecting both the export prices received and the volumes harvested for export.[1288] Meanwhile, hardwood plantations had been marginally stable within the same period.

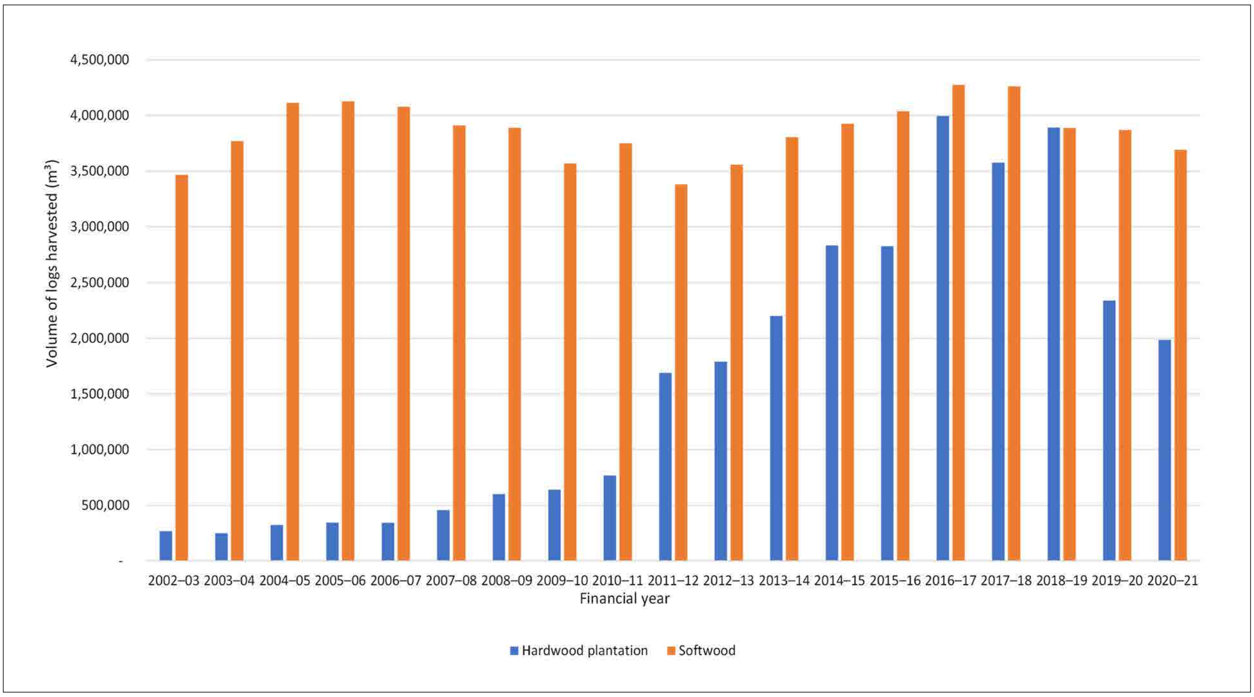


Figure Fo5: Hardwood plantation and softwood logs harvested in Victoria from 2002-03 to 2020-21.[1289]

Newly established plantation areas in Victoria have decreased sharply from a peak of approximately 38,000 hectares in 1999–2000 (Figure Fo6).[1290] Since the 2012–13 financial year, there has been no establishment of new plantation areas. Coupling the impact of 2019-20 bushfires and Victoria's plan to phase out native forest timber harvesting by 2030 will exacerbate the lack of processed timber supplies as there will be no replacement timber available from new plantations ready for harvest for 40 to 80 years. Meanwhile, demand for sawlogs is growing nationally. The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) forecasts a s to the domestic market is forecast to fall short of demand by 2.6 million cubic metres per year between 2045 and 2049 if exports of sawlogs remain at 2015-16 levels. This shortfall could grow to 3.4 million cubic meters per year between 2050 and 2054 with continued growth in demand. To produce such volume, Australia would require 200,000 to 250,000 hectares of new softwood plantations by 2050. ABARES also indicated that new viable softwood plantations are only 2% of the existing estate nationally and around three quarters of the logs harvested from the potential new plantation estate will be exported. This means that the Australian domestic market will become more reliant on imports of sawnwood. ABARES estimates that the import will be doubled in 2050 compared to the volume in 2020 (560,215 m^3 per year). They found that the greatest barrier for new plantation investment is the long delay between investment and final harvest, particularly for long rotation plantations.[1291]

[1288] Commonwealth of Australia 2022, 'Australian forest and wood products statistics - March and June quarters 2022', Canberra, Australian Capital Territory. https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1034165/0 Accessed 1 December 2022.

[1289] Ibid.

[1290] New areas planted excludes replanted areas.

[1291] Ibid

To tackle this, the Victorian Government pledged $110 million in the 2017–18 State Budget as part of the Timber Plantation Establishment Initiative for the Gippsland Plantations Investment Program, a component of the VFP to encourage further investment by the private sector in the establishment of new plantations in Gippsland in order to increase Victoria's future plantation wood supply.[1292] In early 2022, the Commonwealth Government announced $86 million of a federal grants program for establishing new softwood and hardwood plantations in 11 declared regional forest hubs. In Victoria, the Green Triangle, Gippsland and Murray regions were included for funding. Despite the Government's effort to establish new plantations, this has not been reflected on the data. There is an urgent need to develop policy to direct future investment in plantation areas in Victoria. The Victorian Government's announcement to bring forward the end of native timber harvesting by 1 January 2024 is likely to lead to an increase of demand of timber resources from overseas as there is no sign of new plantation establishment. The establishment of new plantation may be targeted to suitable areas where harvesting is efficient and that are isolated in order to assist native forest ecosystems that are highly fragmented.

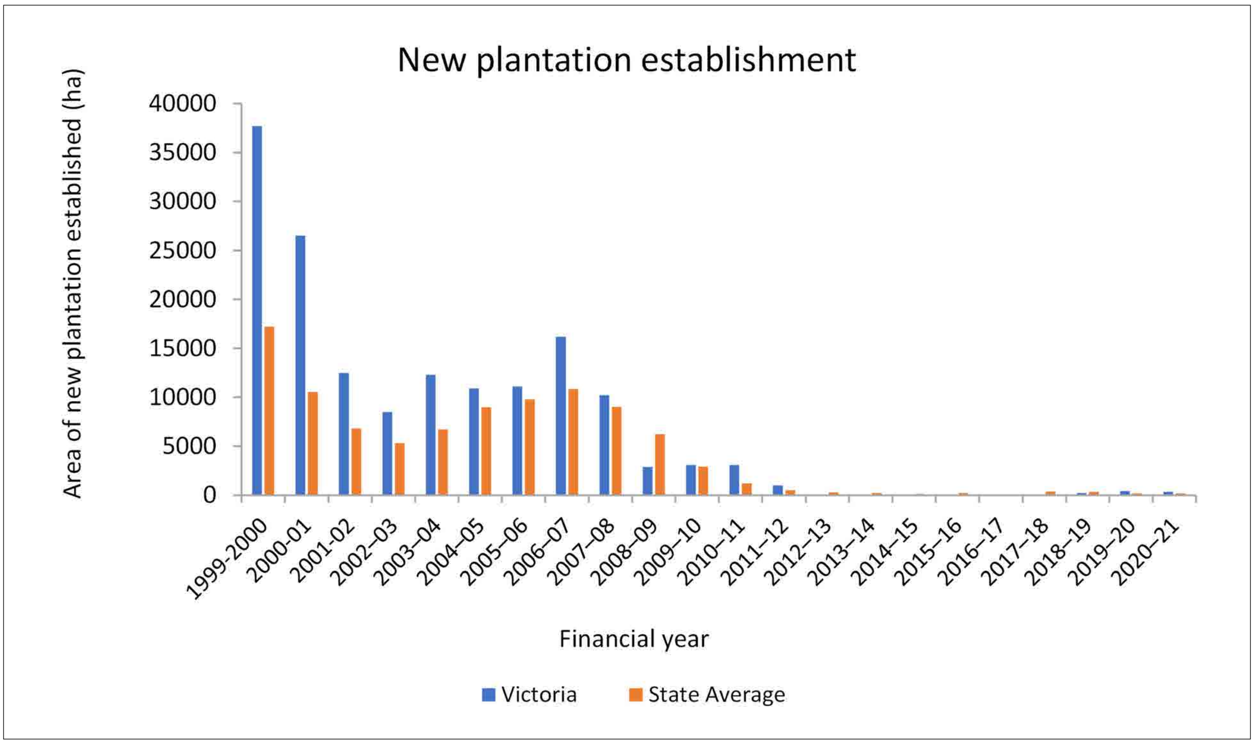


Figure Fo6: Area of new plantation establishment for both hardwood and softwood areas in Victoria from 1999–2000 to 2020–21.[1293]

[1292] Department of Treasury and Finance (DTF) 2017, 'Getting on with the job: Victorian Budget 17/18 overview'. Melbourne, Victoria, https://www.dtf.vic.gov.au/sites/default/files/2018-02/state-budget-overview-2017-18.pdf Accessed 4 December 2018.

[1293] Commonwealth of Australia 2020, 'Data tables - Australian forest and wood products statistics: Sep - Dec quarters 2021', Canberra, Australian Capital Territory, https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1033683/3 Accessed 29 June 2022.

Forests

Indicator Fo:02 Area of forest type by growth stage

Fo:02 Area of forest type by growth stage						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	●	?	🔴	🟡	↗	🟢
Data source(s):	DELWP					
Measure(s):	Change in forest area by growth stage (forest type and height class)					

Why this indicator?

This indicator identifies changes in growth stages within forest types and incorporates issues related to the protection status of old growth forest by EVCs.

Why this assessment in 2023?

There is insufficient information on the changes in growth stages within forest types. Currently, there is only one year of data, which prevents a trend assessment for this indicator.

Summary of State of the Environment 2018 Report assessment

- This indicator reports the growth stage by broad forest type which provides an indication of diversity and balance of growth stages across Victoria's forest estate. The total area of all forest types increased between the assessments using satellite information captured in 2008 and 2013, except for the non-forest type which is described as a traditional forest area that currently has no trees due to disturbances including fire damage.
- Recovery of forests following the 2009 bushfires explains the large reduction in non-forest areas compared with the SoF 2013, which has a baseline year of 2008. Fire-affected areas that regrew post-2008 are likely to have been reclassified from the non-forest type to either the forest or forest potential shrub type.
- Medium and tall eucalypt forests made up 63% of the native forests across Victoria's state forests, parks and conservation reserves, covering an area of 4.6 million hectares. While the total area of medium and tall forest had increased since 2013, the relative proportion of these forest types had declined by approximately 15% due to an increase in low eucalypt, low mixed/other forest and forest potential shrub. This is predominately due to residual mallee regrowth from fires that occurred during the 2002-03 summer bushfire season.

Critical data used for the 2023 assessment

- 2023 data on area of forest type by growth stage

2023 assessment

Understanding the previous and current growth stages of forests in Victoria is important for sustainable forest management. With increasing natural and human-induced disturbances occurring over time, forest dynamics, and particularly species succession, can be drastically altered during regrowth. Knowledge of growth stages, and subsequently forest-recovery conditions, is thus critical in decision-making for land managers to mitigate any ecological losses.[1294]

[1294] Franklin JF, Lindenmayer DB, MacMahon JA, McKee A, Magnusson J, Perry DA, Waide R, Foster DR 2000, 'Threads of continuity: ecosystem disturbances, biological legacies and ecosystem recovery'. *Conservation Biology in Practice*, 1, pp. 8-16.

Forests

This indicator needs to provide information on the area and extent of forest ecosystem types, including successional stage, age class and the nature of tenure or ownership. Reporting the growth stage by broad forest type provides an indication of the diversity and balance of growth stages across Victoria's forest estate. By utilising state-scale remote-sensing data, assessments of the condition of the area of forest type by growth stage at the local and regional scales could differ. This is because the state-scale remote sensing data has the resolution that could cause potential errors when used for finer scales. Here, forest area is classified by height which is considered a proxy for growth stage. The height is classified according to the NFI forest definition into three types depending on stand height:

- low: 2–10 m
- medium: 11–30 m
- tall: > 30 m.[1295]

Table Fo4 shows that medium and tall eucalypt forests make up 87% of the native forests in state forests, whereas the proportion for both forest types decrease to a half in parks and conservation reserves. This is mainly due to the large areas of mallee and non-forest areas. The spatial distribution of forest height in Victoria demonstrates that most medium and tall forests are concentrated on eastern Victoria (Figure Fo7). Three main plantation regions can also be identified on the map: Green Triangle, North East RFA region and Central Highlands RFA region. Mallee areas in the northwest of Victoria consist of low and medium height vegetation. However, due to limited data on the area of forest type by growth stage, trend analysis was not conducted and resulted in a restricted assessment for this indicator.

Table Fo4: Estimated area of broad forest types in state forests and parks and conservation reserves in Victoria during 2023.[1296]

Forest type and height class	State forest (ha)	Parks and conservation reserves (ha)
Low eucalypt	1,800	3,429
Medium eucalypt	2,256,178	1,751,453
Tall eucalypt	522,599	300,461
Unknown eucalypt	8,886	13,448
Mallee	199,768	1,040,801
Low mixed	13,490	29,268
Medium mixed	18,632	58,570
Tall mixed	8,445	12,398
Unknown mixed	73	1,637
Non-forest	91,719	606,588
Other forest - unallocated type	1,652	900
Low other native forest	23,006	57,559
Medium other native forest	32,079	141,608
Unknown other native forest	11,915	32,027
Plantation	2,671	1,057

1295. Department of Agriculture, Fisheries and Forestry (DAFF), 'Australia's national forest inventory', Canberra, Australian Capital Territory, http://www.agriculture.gov.au/abares/forestsaustralia/australias-national-forest-inventory Accessed 3 December 2018.
1296. Department of Energy, Environment and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.

Forests

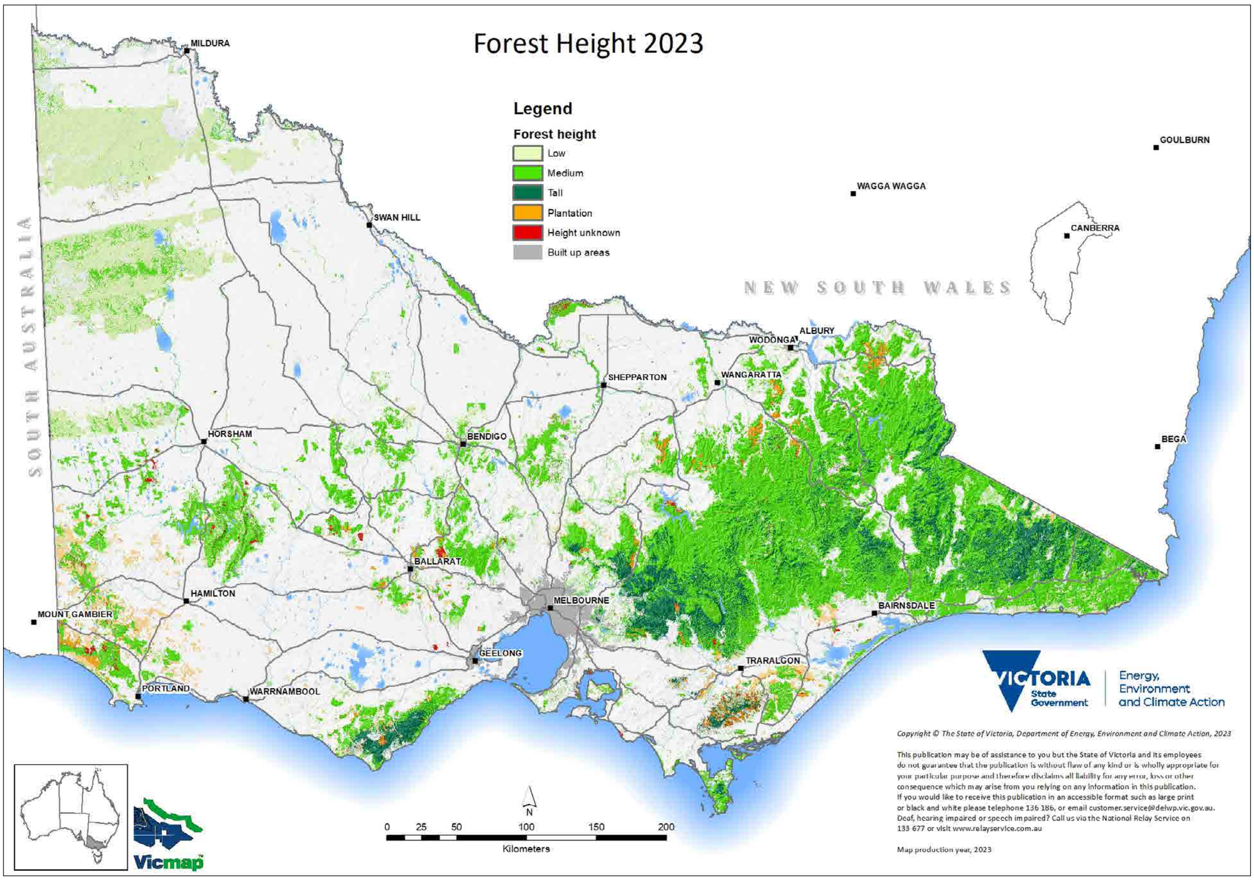


Figure Fo7: Forest height in Victoria during 2023.[1297]

[1297] Department of Energy, Environment and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.

Forests

Indicator Fo:03 Area of forest type by growth stage distribution in protected zones

Fo:03 Area of forest type by growth stage distribution in protected zones

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	↗	●	●	↗	●
Data source(s):	CAPAD, DELWP					
Measure(s):	Change of protected areas by type Implications of changes in protected areas for conservation of threatened species					

Why this indicator?

This indicator provides a status of comprehensive, adequate and representative reserve (CAR) areas and changes in the areas of the reserve.

Why this assessment in 2023?

Informal and formal protection areas have been expanding as a consequence of Victorian Government decisions made during this state of environment reporting period. Although the indicator is to assess change in area of protected zones, it is also important that the addition of area is effective for the conservation and restoration of ecosystems. As part of the modernised Regional Forest Agreements (RFAs), the Victorian Government was required to undertake a review of the comprehensiveness, adequacy and representativeness of the CAR Reserve System in December 2021 (Clause 66G (b) in Central Highlands RFA). Findings from this review have not been incorporated into this assessment as the data were not publicly available when this analysis was conducted.

The 2019–20 bushfires impacted 133 reserves, with between 40% and 100% of their area within the fire extent – including where 91% to 100% of their area was within the fire extent.

As part of the VFP, timber harvesting was immediately excluded from more than 96,000 hectares of high conservation value state forest in November 2019. This is a significant contribution to the informal reserve system that provides protection while a process to determine permanent reservation status of these immediate protection areas (IPAs) is underway. Delays in formal protection of IPAs could lead to the degradation of the values each area holds, including biodiversity.

International Union for Conservation of Nature (IUCN) protected areas increased by 6% between 2010 and 202. More land may be added as a result of the Victorian Government accepting Victorian Environmental Assessment Council (VEAC) assessment recommendations for additional high conservation value area inclusion in formal protection areas.

There remains a need for further research to identify the benefits of different IUCN-protected areas for targeted threatened species.

The quality of data remains unchanged from the SoE 2018 Report as there is no additional information on the benefits of more formal and informal protected areas for threatened species. This would be highly beneficial for indicator assessments.

Summary of State of the Environment 2018 Report assessment

- The proportion of Victorian land assigned formal protection status has risen from less than 1% in the 1950s to 17% in 2016. Between 2000 and 2014, the total area of parks and conservation reserves increased by around 400,000 hectares. Since 2014, additional land parcels have been added due to improvements and clarifications to Crown Land records, changes of the on-ground manager, and the purchasing and reserving of land.
- There was an increase of about 13% in IUCN protected areas overall between 2004 and 2016, indicating better protection of Victoria's forests. Type V (protected landscape/seascape) and Type VI (protected area with sustainable use of natural resources) areas demonstrated the greatest level of increase, by more than 200% each. Type Ia (strict nature reserve) and Type III (natural monument or feature) areas increased gradually.[1298]
- Currently, there is little evidence on how well these classifications protect species. Detailed research is necessary to identify the benefits of different IUCN protected areas for target species, such as those on the IUCN Red List of Threatened Species.

[1298] Type Ia area is protected for biodiversity and strictly controlled to avoid any intervention and Type III area is to protect a specific natural monument, such as a cave.

Critical data used for the 2023 assessment

- The Collaborative Australian Protected Areas Database (CAPAD)
- Special Protection Zone from Forest Management Zoning (FMZ100) dataset
- Forests of Australia 2022

2023 assessment

IUCN protected areas

Australia compares favourably internationally with respect to forest conservation.[1299] The IUCN is the global authority on the status of the natural world. The IUCN defines a protected area as a clearly defined geographic space that is recognised, dedicated and managed through legal or other effective means to achieve the long-term conservation of nature and associated ecosystem services and cultural values. Under Australia's Strategy for the National Reserves System 2009–2030, all state and territory governments have agreed to adopt these IUCN international standards for defining and reporting areas of protected area management. All Victorian formal reserves are assigned an IUCN protected area category on the basis of its protection status and primary land management. The IUCN categories assigned to a particular area may be subject to refinement from time to time. Informal reserves are not assigned an IUCN protected area category. The most recent map of IUCN protected areas is presented in Figure Fo8.

There was roughly a 6% increase in overall IUCN protected areas in Victoria between 2010 and 2020 (Table Fo5). The area of Type V (protected landscape/seascape) and Type VI (protected area with sustainable use of natural resources) areas increased the most (more than 70%). Meanwhile, Type Ia (Strict Nature Reserve) and Type IV (habitat or species management area) areas increased gradually. Type Ia area is protected for biodiversity and strictly controlled to avoid any intervention. Type II (National parks) has the largest contribution to Victoria's IUCN areas. This category includes 45 national parks, 26 state parks and 13 marine national parks. Over a decade (2010-2020), around 50,000 hectares was added to the category. Overall, the total increase in IUCN area indicates that there will be more protection in Victoria's forests, which is similar to the findings from SoE 2018 Report. There have been significant management efforts delivered for national parks including the management of invasive species, cultural values and threatened species and communities and the continued development of conservation action plans for all parks.

The 2019-20 bushfires burnt around 421,462 hectares. The Independent Panel for the major event review of the 2019-20 bushfires in Victoria found that, among national heritage places, the Australian Alps National Parks (AANP) were heavily impacted, totalling 330,434 hectares out of 857,048 hectares. Among the impacted areas, about 225,630 hectares (26%) of the AANP was burnt during the 2019–20 bushfires, of which approximately 104,805 hectares (12%) was impacted by high-severity fires (Table Fo6). The Avon Wilderness Park and Baw Baw National Park components of the AANP were not impacted. The greatest impact by extent was recorded in the East Gippsland RFA region. More than half of the AANP extent (117,233 ha) in this RFA region was impacted by fire. Around 40% of this fire-affected area was severely impacted, mostly concentrated in or around the Snowy River National Park. A fifth of the overall AANP extent within the Gippsland RFA region was impacted by fire, and more than half of the fire-affected area was burnt by high-severity fires (38,319 ha). Table Fo6 shows a number of large areas that were impacted by high-severity fire. The largest areas within Victoria's component of the AANP that were impacted by high-severity fires are located in a large part of Snowy River National Park, areas west of Gelantipy, the north and north-western part of Cobberas, areas around Davies Plain, the eastern side of Lake Dartmouth, near Mount Pinnibar, most of the Bundara region, Mount Tabletop, Mount Selwyn, north of Wongungarra, the west of Mount Buffalo National Park, and east of Abbeyard.

[1299] International Union for Conservation of Nature, 'Oceania', Switzerland, https://www.iucn.org/our-work/region/oceania Accessed 19 April 2023.

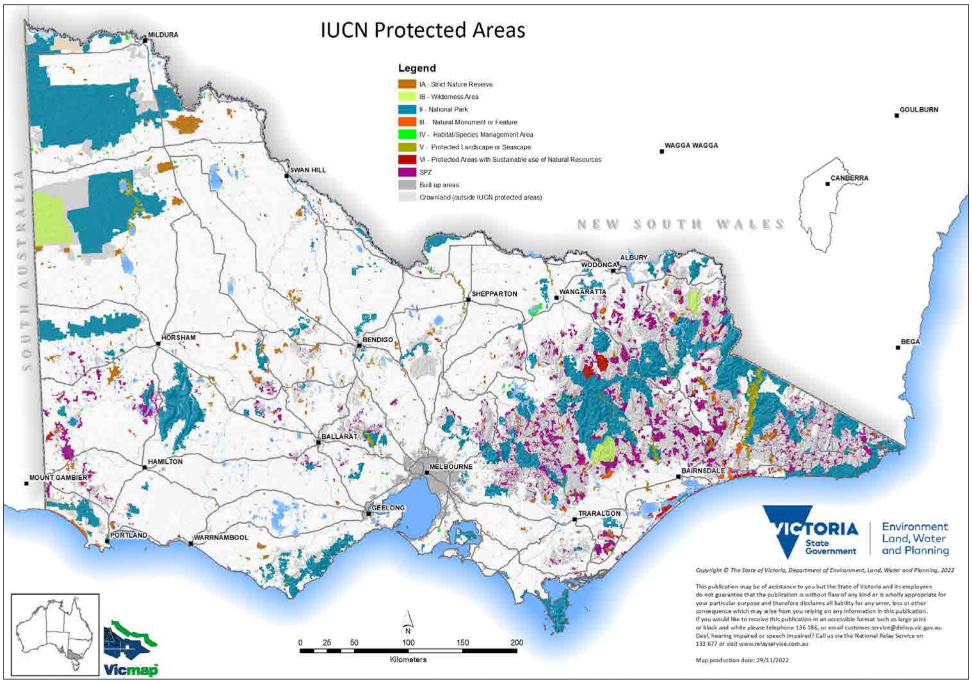


Figure Fo8: Victorian terrestrial IUCN protected areas in 2022.[1300]

Table Fo5: Victorian protected areas by IUCN category and informal SPZ reserves between 2010 and 2020.[1301]

Formal protection	**Area (ha)**						
IUCN category	**2010**	**2012**	**2014**	**2016**	**2018**	**2020**	**Proportion of forest cover (%)a**
IA	380,700	388,600	421,600	421,500	475,338	475,566	82.9
IB	815,700	815,500	740,900	740,900	791,856	791,856	89.0
II [b]	3,073,005[1302]	3,106,252[1303]	3,114,414[1304]	3,114,479[1305]	3,121,786[1306]	3,121,802[1307]	90.7
III	51,300	78,000	75,500	75,600	79,778	79,838	81.3
IV	43,700	47,400	47,500	47,500	47,799	58,221	52.4
V	49,200	26,800	135,200	135,200	153,134	153,134	72.3
VI	85,100	130,600	208,300	206,200	141468.8	143410.6	42.6
All IUCN protected areas	4,498,705	4,593,152	4,743,414	4,535,179	4,811,158	4,823,827	87.0
Informal protection							
SPZ	783,100	753,100	747,300	761,100	764,119	772,597	98.5
Total area	5,281,805	5,346,252	5,490,714	5,296,279	5,575,277	5,596,424	88.6

[a] *Proportion of forest cover refers to the proportion of this reserve class under forest*

[b] *All figures are from DELWP except for information on IUCN Category II where footnotes are provided.*

1300. Department of Energy, Environment and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.
1301. Ibid.
1302. Department of Sustainability and Environment (DSE) 2010, 'National Parks Act annual report 2010', Melbourne, Victoria.
1303. Department of Sustainability and Environment (DSE) 2012, 'National Parks Act annual report 2012', Melbourne, Victoria.
1304. Department of Environment and Primary Industries (DEPI) 2014, 'National Parks Act annual report 2014', Melbourne, Victoria.
1305. Department of Environment, Land, Water and Planning (DELWP) 2016, 'National Parks Act annual report 2016', Melbourne, Victoria.
1306. Parks Victoria (PV) 2019, 'National Parks Act annual report 2018-19', Melbourne, Victoria.
1307. Parks Victoria (PV) 2021, 'National Parks Act annual report 2020-21', Melbourne, Victoria.

Table Fo6: Impact of the 2019-20 bushfires on Australian Alpine National Parks by fire extent and high severity.[1308]

Australian Alpine National Parks		Central Highlands RFA (ha)	East Gippsland RFA (ha)	Gippsland RFA (ha)	North East RFA (ha)	Total area (ha)
Alpine National Park	High fire severity	-	16,484	38,319	15,630	70,433
	Fire extent	-	29,287	67,349	32,538	129,174
	Overall extent	-	111,391	313,610	237,481	662,482
Avon Wilderness Park	High fire severity	-	-	-	-	-
	Fire extent	-	-	-	-	-
	Overall extent	-	-	39,566	-	39,566
Baw Baw National Park	High fire severity	-	-	-	-	-
	Fire extent	-	-	-	-	-
	Overall extent	12,665	-	118	-	12,784
Mount Buffalo National Park	High fire severity	-	-	-	3,759	3,759
	Fire extent	-	-	-	8,509	8,509
	Overall extent	-	-	-	27,483	27,483
Snowy River National Park	High fire severity	-	30,613	-	-	30,613
	Fire extent	-	87,947	-	-	87,947
	Overall extent	-	114,734	-	-	114,734
Total	High fire severity	-	47,098	38,319	19,389	104,805
	Fire extent	-	117,234	67,349	41,047	225,629
	Overall extent	12,665	226,124	353,294	264,964	857,048

Key additions to CAR Reserve System

In 2019, as part of the VFP, timber harvesting was excluded from more than 96,000 hectares of high conservation value state forest in IPAs. This is a major contribution to the informal reserve, while a process to determine permanent reservation status of IPAs is underway. The creation of IPAs in the Strathbogie Ranges, the Central Highlands, Mirboo North and East Gippsland IPAs is the first step in phasing out timber harvesting in all native forests on public land (Figure Fo9). The IPAs include existing areas of SPZ within their boundaries and, when combined with the additional areas of GMZ and SMZ where timber harvesting was excluded, it brings the total area of forest protected in IPAs to more than 146,000 hectares.

The IPAs are a new conservation measure described in the FFG Greater Glider Action Statement.[1309] The Greater Glider Action Statement was finalised by DELWP in November 2019, prior to the 2019–20 bushfires impacting eastern Victoria.

The Victorian Government is undertaking a consultation process to determine the future use and management of the IPAs. As part of this process, VEAC has conducted assessments of IPA values with community engagement undertaken by the Eminent Panel for Community Engagement (EPCE). So far, two IPAs have been assessed through this process (Mirboo North and the Strathbogie Ranges).[1310]

1308. Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

1309. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Greater glider *(Petauroides Volans subsp Volans)*, action statement no. 267', Melbourne, Victoria https://www.environment.vic.gov.au/__data/assets/pdf_file/0019/440371/267-Greater-Glider-2019-Action-Statement.pdf Accessed 4 July 2022.

1310. Victorian Environmental Assessment Council (VEAC) 2022, 'Assessment of the values of the Strathbogie Ranges and Mirboo North Immediate Protection Areas', https://veac.vic.gov.au/investigations-assessments/current-assessments/investigation/assessment-of-the-values-of-immediate-protection-areas-in-the-strathbogie-ranges-and-mirboo-north Accessed 5 December 2022.

Forests

The EPCE, in partnership with Traditional Owners, undertook community consultation and considered VEAC's assessments for these IPAs and recommended that:

- The Strathbogie Ranges IPA be managed in accordance with the principles and purposes of a new Cultural Reserve public land category. As a 'cultural reserve' public land category does not currently exist in Victoria's public land framework, the panel recommended the definition of the reserve should be developed through the Public Land Act, in partnership with Traditional Owner Groups.
- The Mirboo North IPA be managed in accordance with a 'conservation park' public land category.

The Victorian Government is currently considering these reports and recommendations by the EPCE.

Consequently, neither of the two IPA areas assessed by VEAC have secure permanent protection. Delays in formal protection of these, and other IPAs, could lead to the degradation of the values held by each IPA, including biodiversity. As IPAs contribute to the informal reserve system, these areas do not contribute as yet to Victoria's formal reserve system (e.g. IUCN protected areas) until permanent protection is afforded.

The Victorian Government is immediately protecting more than **96,000 hectares** of high conservation value forest from commercial timber harvesting in Immediate Protection Areas. This is in addition to existing protections and brings the total area of forest protected in Immediate Protection Areas to more than **146,000 hectares**. The creation of these Immediate Protection Areas – in the **Strathbogie Ranges, Central Highlands, Mirboo North and East Gippsland** – is the first step in phasing out harvesting in all native forests on public land by 2030.

VICTORIA State Government
Environment, Land, Water and Planning

Figure Fo9: IPAs in Victoria during 2019.[1311]

[1311] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Immediate protection areas in Victoria', https://www.delwp.vic.gov.au/__data/assets/pdf_file/0027/556425/immediate-protection-area-maps-and-facts.pdf Accessed 5 December 2022.

Forests

The SoE 2018 Report identified a need for further research to identify the benefits of different IUCN protected areas for targeted threatened species. This was also raised in the Major Event Review of 2019-20 bushfires in Victoria. As a part of the modernised RFA, the Victorian Government was required to undertake a review of the comprehensiveness, adequacy and representativeness of the CAR reserve system in December 2021 (Clause 66G (b) in Central Highlands RFA). Findings from this review have not been incorporated as this information was not publicly available when this indicator assessment was conducted.

The 2019-20 bushfires: impacts and responses

Table Fo7 shows that Victoria's forested areas cover 8.222 million hectares, with 7.622 million hectares in native forest, 415,000 hectares in plantations and 162,000 hectares in the 'other forest' category. The 2019–20 bushfires burnt through 1.457 million hectares of Victoria's forests, almost all of which were covered in native forest. Almost all of the fire extent resulting from the 2019–20 bushfires was in the forests of north-eastern and far-eastern Victoria. The largest fire in western Victoria was between Warrnambool and Portland in the Budj Bim Cultural Landscape World Heritage Area and burnt across more than 7,000 hectares.

Table Fo7: Area and percentage of Victoria's forests burnt by forest category during the 2019–20 bushfires as at 28 April 2020.[1312]

Total forest area ('000 ha)				Total area burnt ('000 ha)				Proportion of total forest area burnt (%)			
Native forest	Commercial plantation	Other forest	Total forest	Native forest	Commercial plantation	Other forest	Total forest	Native Forest	Commercial plantation	Other forest	Total forest
7,645	415	162	8,222	1,444	10	3	1,457	19	2.4	2.0	18

Table Fo8 presents data on the extent of the bushfires across Victoria's six forest tenure categories:

- Multiple-use public forest: Crown Land managed for a range of values including timber harvesting, water supply, conservation, recreation and environmental protection. Significant proportions of multiple-use forests are informal reserves within state forests in Victoria whose management is overseen by DEECA and where wood harvesting is not permitted.
- Nature conservation reserve: Crown Land managed by PV and formally reserved for environmental, conservation and recreational purposes, including national parks and nature reserves.
- Other Crown Land: Crown Land held for a variety of purposes, including utilities, mining, water catchments and use by Indigenous communities and whose management is overseen by DEECA.
- Private forest: forest on privately owned land, including Indigenous owned land.
- Leasehold forest: forest which is privately managed on leased Crown Land and is generally used for grazing.
- Unresolved tenure: forest for which ownership status has not been determined.[1313]

The main tenure categories by area in Victoria are multiple-use public forest (state forests) and nature conservation reserves (e.g. national parks). These are also the two forest tenure categories most affected by the 2019–20 bushfires, as shown in Table Fo8.

[1312] Commonwealth of Australia 2020, 'Forest fire area data for the 2019–20 summer bushfire season in southern and eastern Australia', Canberra, Australian Capital Territory, https://www.agriculture.gov.au/sites/default/files/documents/ABARES_Forest_Fire_area_2019_20_data_tables_28Apr.xlsx Accessed 19 April 2023.

[1313] Department of Agriculture, Fisheries and Forestry (DAFF), 'Australia's forests', Canberra, Australia, https://www.agriculture.gov.au/forestry/australias-forests Accessed 19 April 2023.

Table Fo8: Area and percentage of Victoria's native forest burnt by the 2019–20 bushfires by forest tenure.[1314]

Native forest area ('000 ha)	
Leasehold forest	0
Multiple-use public forest	3052
Nature conservation reserve	3367
Other Crown land	241
Private forest	984
Unresolved tenure	0
Total native forest area	7645
Native forest in burnt area ('000 ha)	
Leasehold Forest	0
Multiple-use public forest	878
Nature conservation reserve	496
Other Crown land	13
Private forest	57
Unresolved tenure	0
Total native forest in burnt area	1444
Proportion of native forest in burnt area (%)	
Leasehold Forest	0
Multiple-Use Public Forest	29
Nature Conservation Reserve	15
Other Crown Land	5.3
Private Forest	5.8
Unresolved Tenure	13
Total percentage	19

Table Fo9 presents data on the coverage of the four components in Victoria's five RFAs and the spatial impact of the 2019–20 bushfires. Table Fo10 provides further details on the impacts of the 2019–20 bushfires within national parks, conservation reserves and state forests. It reveals that 133 reserves had between 40% and 100% of their area within the fire extent, including where 91% to 100% of their area was within the fire extent.

[1314] Commonwealth of Australia 2020, 'Forest fire area data for the 2019–20 summer bushfire season in southern and eastern Australia', Canberra, Australian Capital Territory, https://www.agriculture.gov.au/sites/default/files/documents/ABARES_Forest_Fire_area_2019_20_data_tables_28Apr.xlsx Accessed 19 April 2023.

Table Fo9: Impacts of 2019-20 bushfire season on the CAR Reserve system across all RFA regions.[1315]

Car Reserve system component	Current fire extent (ha)	High severity fire (ha)	Total area across Vic (ha)
Dedicated Reserves: National parks and nature conservation reserves	482,094	285,462	3,900,480
Permanent protection on private land	404	130	49,025
Informal Reserves: SPZ	203,758	127,966	765,900
Prescriptions (modelled exclusions and rainforest, per Management Standards and Procedures for timber harvesting operations in Victoria's state forests)*	193,375	12,359	629,120
IPAs (additional new protected areas, as identified in the Greater Glider Action Statement No. 267)*	44,169	31,255	95,107

** Prescriptions and the IPAs are not part of the CAR Reserve System but are instead considered to be related components, according to DELWP.*

Table Fo10: Impacts of 2019-20 bushfire season on national parks, conservation reserves and state forests in Victoria as reported in 2020.[1316]

Reserves and state forests	Percentage of reserve within fire extent			
	40-60%	61-80%	81-90%	91-100%
National parks and nature conservation reserves (per National Parks Act)	3 reserves	4 reserves	5 reserves	25 reserves
Other conservation reserves (non-protected areas, such as regional parks, lake parks and historical reserves)	3 reserves	5 reserves	1 reserve	36 reserves
State forests	6 reserves	6 reserves	9 reserves	30 reserves

The monitoring, evaluating and reporting (MER) report also identified that in the fire-affected RFA regions there are seven EVCs classified as having a vulnerable or endangered status and include the valley grassy forest, lowland forest, cut-tail forest, damp forest and riparian forest EVCs in the East Gippsland RFA, the montane grassy shrubland in Gippsland RFA, and the montane wet forest in the North East RFA. These areas have less than 60% reserve of their extent within CAR reserves and were heavily impacted (greater than 50% of their extent impacted by fire) by the 2019–20 bushfires.

The JANIS criteria specifies that forest ecosystems that are recognised as vulnerable should be reserved for at least 60% of their remaining extent. The MER report found that the EVC that has the lowest protection under the CAR reserve system, and was significantly impacted by high-severity fire, was the montane grassy shrubland EVC (Gippsland RFA), which had no protection under the CAR reserve system and 56% of its extent impacted by severe fire (Class 5 and Class 682). The MER report recommended that the Victorian Government develop an action plan to expand protection areas for these seven EVCs.

[1315] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victoria's bushfire emergency: biodiversity response and recovery-version 2', Melbourne, Victoria, https://www.wildlife.vic.gov.au/__data/assets/pdf_file/0030/484743/Victorias-bushfire-emergency-Biodiversity-response-and-recovery-Version-2-1.pdf Accessed 19 April 2023.

[1316] Ibid.

Forests

Indicator Fo:04 Fragmentation of native forest cover

Fo:04 Fragmentation of native forest cover						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🔴	↙	🟡	🔴	?	🟡
Data source(s):	DELWP					
Measure(s):	Forest fragmentation by bioregion and tenure Information on genetic risk assessment for threatened species					

Why this indicator?

Forest fragmentation poses significant threats to biodiversity and endangers the sustainability of ecological goods and services from forested land. This indicator assesses genetic risks to 1,100 Victorian flora and fauna species.

Why this assessment in 2023?

Of Victoria's total land area, about 61% and 27% was classified as interior forest and forest edge in 2022, respectively. Bioregions with the highest proportion of interior forest among forested areas are concentrated in the eastern part of Victoria. This includes the Australian Alps (87%), the South East Corner (81%) and the South Eastern Highlands (78%) bioregions. The Riverina is the most fragmented bioregion and has the highest proportion of forest patches (27%). Results show that state forests and parks and reserves are of high importance for biodiversity conservation due to the high proportion of interior areas in all bioregions.

The genetic risk index shows that approximately 30% of the assessed species have high or very high genetic risk categories. The assessment of the risk to genetic health for 138 species identified by the Victorian and Commonwealth governments is considered of immediate concern as a result of the 2019–20 bushfires.

Due to the technical barriers to ensure accuracy, only a state-scale comparison was possible. The state-level data from 2018 and 2022 demonstrate a large increase in the area of forest edge (~1.26 million ha) and a decrease of interior areas (~0.7 million ha). The increase in forest edge and the decrease in the total interior area may be a result of the 2019–20 bushfires as well as other major factors, including changes in forest-extent mapping methodology and data resolution. In addition, many species increased their genetic risk as a result of the 2019–20 bushfires.

No comprehensive status assessment was conducted due to an absence of functional connectivity assessment in Victoria for different ecosystems, as they have different response patterns to different conditions of fragmentation. The genetic risk index was used as an alternative approach.

Forest fragmentation data were produced for two years (2018 and 2022) by bioregion and tenure, but the comparison of the two years of data were possible at the state scale only, as data resolution deteriorated from 30 m in 2018 to 100 m in 2022, and different analytical methods were applied in the two corresponding years. This makes data confidence rated as fair.

Summary of State of the Environment 2018 Report assessment

- Due to differences in mapping methodology and improvements in satellite imaging resolution, it was not possible to compare the data for the SoE 2018 Report with that of previous years. As a result, it was challenging to assess overall trends in forest fragmentation in different bioregions and for different forest types.
- Peer-reviewed journal papers have found that several threatened species are at risk due to forest fragmentation.

Critical data used for the 2023 assessment

- 2023 Victorian forest fragmentation data by bioregion and tenure
- Genetic risk assessment of 1,100 Victorian flora and fauna species

2023 assessment

Forest fragmentation is a metric to describe forest quality using the assumption that large continuous areas support more interacting populations and larger, more resilient populations.[1317, 1318, 1319] Forest loss and the deterioration of forest health by way of increased fragmentation poses significant threats to biodiversity and endangers the sustainability of ecological goods and services from forested land.[1320, 1321] This indicator measures the loss of forest cover and the spatial configuration of that loss, which together indicates the level of fragmentation in Victoria's forests and the likely impacts on forest-dependent species. Statewide forest fragmentation in Victoria is presented in Figure Fo10 which shows the extent of forest fragmentation across the state during 2022.

Analysis of the satellite Landsat data captured at a statewide scale in 2023 (Table Fo11 and Table Fo12) shows:

- On average, approximately 61% of Victoria's forest cover is classed as interior (e.g. core, non-fragmented forest) and about 27% as edge area, with boundaries between interior forest and non-forest land cover (Table Fo8). Twenty-three percent of Victoria' total land area (the sum of Victoria's bioregions) is interior forest and about 10% is edge area (Table Fo12).
- Bioregions with the highest proportion of interior forest among forested areas are concentrated in the eastern part of Victoria. This includes the Australian Alps (87%), South East Corner (81%) and South Eastern Highlands (78%). The Riverina is the most fragmented bioregion and also has the highest proportion of forest patches (27%).
- The most fragmented areas are on other public lands in each bioregion (Figure Fo11). On average, state forests had the highest proportion of interior areas except for the Murray Darling Depression, Naracoorte Coastal Plain, and parks and reserves. The proportion of interior area drops sharply on other public lands which includes Commonwealth land, other public land, and areas not classified or unattributed. The fragmentation information by tenure classes indicates the importance of state forests and parks and reserves for biodiversity.

Since there is no continuous and consistent supply of forest extent data from a single source, forest extent mapping methodology, including resolution, have been variable between years. In particular, the resolution has deteriorated from 30 m in 2018 to 100 m in 2022. Forest fragmentation by bioregion and tenure classes are not comparable with the past data (2013 and 2018) as the classified categories have been changed in 2022. This, as well as the deterioration of mapping resolution, creates difficulties in providing an overall trend of the level of forest fragmentation in different bioregions and forest types. Although this issue was highlighted in SoE 2018 Report, it has not yet been addressed. With an absence of a trend analysis, as well as a lack of a scientific assessment of the current status and its implications to threatened species conservation, the Victorian Government does not have a clear understanding of forest fragmentation which reduces its ability to develop and implement a strategic, evidence-based approach in managing forest fragmentation in Victoria.

1317. Forman RTT, Godron M 1986, 'Landscape ecology', John Wiley, New York, United States of America.
1318. Turner MG 1989, 'Landscape ecology: the effect of pattern on process'. *Annual Review of Ecology and Systematics*, 20, pp. 171-197.
1319. Levin SA 1992, 'The problem of pattern and scale in ecology'. *Ecology*, 73(6), pp. 1943-1967.
1320. Harris LD 1984, 'The fragmented forest. Island biogeography theory and the preservation of biotic diversity'. University of Chicago Press, Chicago, Illinois, United States of America.
1321. Lovejoy TE, Bierregaard RO, Rylands AB, Malcolm JR, Quintela CE, Harper LH, Brown KS, Powell AH, Powell GVN, Schubart HOR, Hays MB 1986, 'Edge and other effects of isolation on Amazon forest fragments'. In Soulé ME, editor. Conservation biology: The science of scarcity and diversity. Sinauer Associates, Sunderland, Massachusetts, USA.

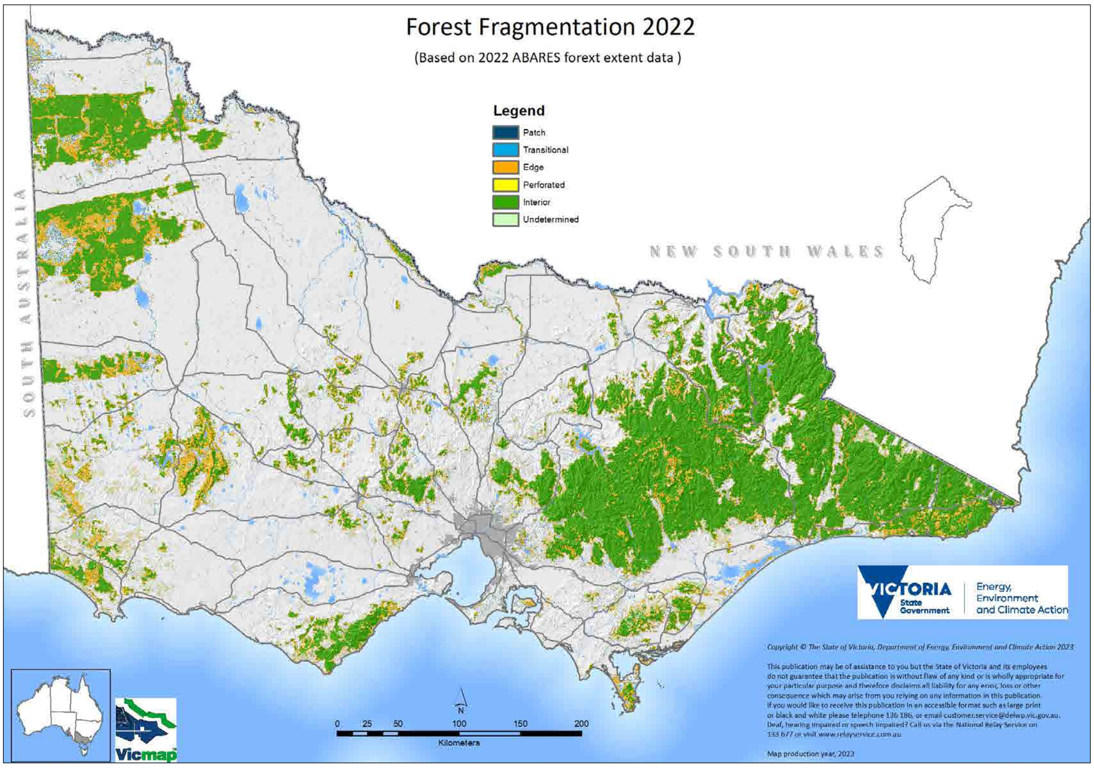
Table Fo11: Forest fragmentation in Victoria by bioregion in 2023.[1322]

Bioregion	Edge (ha)	Interior (ha)	Patch (ha)	Perforated (ha)	Transitional (ha)	Bioregion area (ha)	Forest area (ha)
Australian Alps	80,007	602,334	1,005	8,399	2,826	714,271	694,571
Flinders	13,251	8,969	1,248	695	2,241	41,157	26,404
Murray Darling Depression	476,057	923,701	113,698	35,138	87,429	6,356,148	1,636,023
Naracoorte Coastal Plain	137,616	98,357	5,851	10,844	13,930	421,352	266,598
NSW South Western Slopes	80,575	59,623	14,902	2,593	18,793	565,869	176,486
Riverina	84,110	31,604	57,044	6,924	28,374	2,507,926	208,056
South East Coastal Plain	145,040	86,168	42,004	7,755	38,741	1,749,585	319,710
South East Corner	193,077	987,800	9,740	12,434	16,875	1,395,433	1,219,926
South Eastern Highlands	434,107	1,949,947	42,113	20,324	59,755	3,178,804	2,506,246
Victorian Midlands	548,241	376,552	99,122	25,500	114,755	3,468,873	1,164,170
Victorian Volcanic Plain	63,845	37,777	20,070	2,127	18,925	2,355,992	142,744
Grand total	2,256,636	5,163,088	407,212	133,748	402,953	22,771,445	8,363,638

Table Fo12: Victorian forest fragmentation as the percentage of total forest area (ha) by bioregion 2023.[1323]

Bioregion	Patch (%)	Transitional (%)	Edge (%)	Perforated (%)	Interior (%)
Australian Alps	0.14	0.41	11.52	1.21	86.72
Flinders	4.73	8.49	50.19	2.63	33.97
Murray Darling Depression	6.95	5.34	29.1	2.15	56.46
Naracoorte Coastal Plain	2.19	5.23	51.62	4.07	36.89
NSW South Western Slopes	8.44	10.65	45.66	1.47	33.78
Riverina	27.42	13.64	40.43	3.33	15.19
South East Coastal Plain	13.14	12.12	45.37	2.43	26.95
South East Corner	0.80	1.38	15.83	1.02	80.97
South Eastern Highlands	1.68	2.38	17.32	0.81	77.80
Victorian Midlands	8.51	9.86	47.09	2.19	32.35
Victorian Volcanic Plain	14.06	13.26	44.73	1.49	26.46
Grand total	4.87	4.82	26.98	1.60	61.73

1322. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.
1323. Ibid.


Forest Fragmentation 2022

(Based on 2022 ABARES forext extent data)

Map production year, 2023

Figure Fo10: Forest fragmentation in Victoria during 2022.[1324]

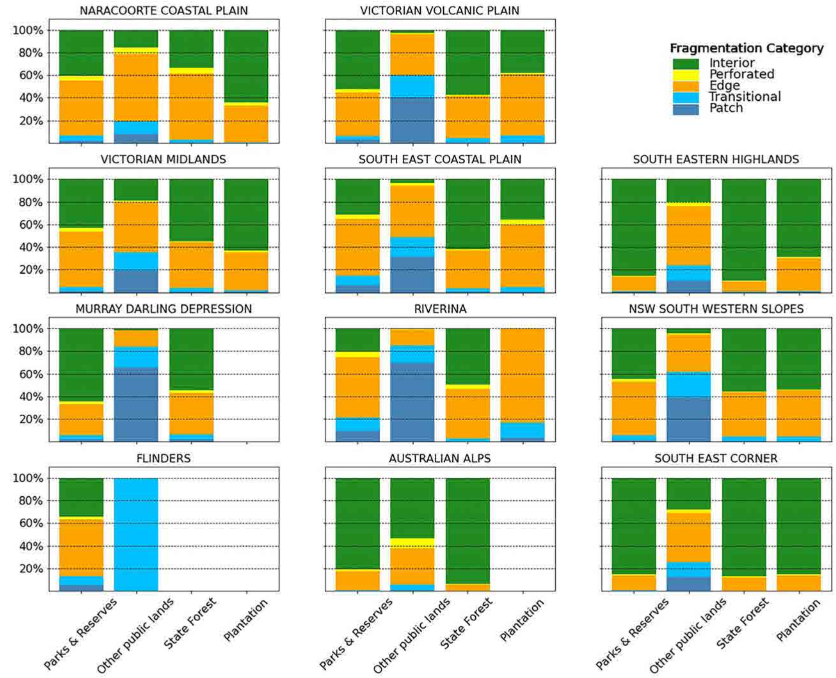


Figure Fo11: Relative proportion of forest fragmentation categories by region and land type in Victoria during 2022.[1325]

[1324] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

[1325] Ibid.

Fragmentation of native forest cover can often correlate to fragmentation in populations of Victorian flora and fauna, however, both the unique genetic characteristics and the dispersal patterns during different life stages of each species means a causative link may be difficult to ascertain. As genetic data are limited, this indicator cannot be expanded to a species scale, although, an assessment of genetic risk for 1,100 Victorian flora and fauna has been undertaken utilising a wide range of databases in order to inform genetic intervention strategies.[1326] This research was the basis for DELWP's Genetic Risk Index noting that there is a high degree of uncertainty in calculations for some species due to very limited data for plants, invertebrates and many threatened species. Despite these limitations, the assessment does show that around 30% of assessed species fall into the high or very high genetic risk categories. Updates to the risk assessment of genetic health for 138 species identified by the Victorian and Commonwealth governments found them to be of immediate concern after 2019-20 bushfire event.[1327]

In 2019, the RFA Scientific Advisory Panel indicated that they are not aware of any comprehensive assessments of the configuration of the Victorian CAR reserve system in terms of edge effects on functional connectivity (measures of actual ecological connections and interactions). It requires detailed analyses which takes into account each ecosystem's different response patterns towards varying levels of fragmentation. The Panel recommended some indices of connectivity could be calculated using existing DEECA databases for comparison across forest tenures. However, this has not been progressed.

Genetic diversity

Loss of genetic diversity negatively impacts on the ability of species to adapt to environmental change and for society to maximise the potential benefits available from forest-dependent species. It also makes forest ecosystems less resilient to the change. This theme will demonstrate Victorian Government's effort for species conservations.

[1326] Kriesner P, Weeks A, Razeng E, Sunnucks P 2020, 'Assessing genetic risks to Victorian flora and fauna', https://www.environment.vic.gov.au/__data/assets/pdf_file/0029/518492/Genetic-Risk-Index-Report.pdf Accessed 15 August 2022.

[1327] Kriesner P, Weeks A 2020, 'Genetic risks to Victorian biodiversity following the 2019/20 bush fire emergency', https://www.environment.vic.gov.au/__data/assets/pdf_file/0030/518493/Genetic-Risk-Index-Updated-Fire-Report.pdf Accessed 15 August 2022.

Forests

Indicator Fo:05 Number of in-situ and ex-situ conservation efforts for forest-dependent species

Fo:05 Number of in-situ and ex-situ conservation efforts for forest-dependent species

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴	?	🟡	●	?	🔴

Data source(s):	DELWP, VicForests, Zoos Victoria
Measure(s):	Effectiveness of in-situ and ex-situ conservation efforts for conservation of forest-dependent species

Why this indicator?

This indicator describes the extent of in-situ and ex-situ conservation efforts for native forest-dependent species. In-situ (on-site) conservation efforts include management of parks and other protected areas, genetic and ecological conservation areas as well as timber harvesting areas and harvesters in state forests that comply with the Code of Practice for Timber Production 2014. Ex-situ (off-site) conservation measures include seed banks, seed orchards, conservation breeding and clonal archives.

Why this assessment in 2023?

Despite government and stakeholder investment towards improving ecological management of native timber harvesting, the spatial extent of native vegetation areas, invasive species management and conservation breeding programs, the conservation status of forest-dependent species is deteriorating and is assessed as poor.

Sufficient information was found from publicly available sources. However, it is unclear whether the conservation efforts are a complete picture of the activities being delivered in Victoria, and whether their outcomes have been fully evaluated.

Summary of State of the Environment 2018 Report assessment

- Previous SoF reports used the Actions for Biodiversity Conservation system to describe the extent of conservation efforts for native species. However, the system was decommissioned in 2013, making comparisons with past data difficult. The data collated by DELWP's Natural Environment Programs teams shows the level of management activity for each forest-dependent threatened species for eight action categories.
- The two levels of management activity provide a qualitative measure of conservation efforts in Victoria. However, it is difficult to evaluate whether the current approach has a strong impact on achieving positive species conservation outcomes and/or improvement in conservation classification. The management activities need to be linked with state-scale monitoring programs to evaluate the effectiveness of in-situ and ex-situ conservation efforts.

Critical data used for the 2023 assessment

- Progress of in-situ conservation efforts for Protecting Victoria's Environment – Biodiversity 2037
- Native timber harvesting area with variable retention methods
- Seed banking status
- Conservation breeding and/or translocations program for forest-dependent species

Forests

2023 assessment

In-situ conservation effort

Released in April 2017, Protecting Victoria's Environment – Biodiversity 2037 (Biodiversity 2037) is the Victorian Government's response to addressing the decline in the state's biodiversity.[1328] The plan presents a long-term vision for Victoria's biodiversity supported by two goals: 'Victorians value nature' and 'Victoria's natural environment is healthy.' Biodiversity 2037 sets statewide targets and contributing targets for both goals, with contributing targets reviewed and updated every five years. However, data collected under the plan is for 'any native vegetation including forests', thus, any achievements of targets does not indicate direct improvements in forests. More information on the plan's targets and goals can be found in the 'Biodiversity' chapter of this report.

DELWP's 2020 report on the implementation of Biodiversity 2037 revealed that there was a net annual loss of 6,660 habitat hectares of native vegetation in Victoria in 2019.[1329, 1330] This is around a 1,600-hectare improvement from the average annual loss reported by DELWP in 2015. The main contributor of native vegetation loss was from entitled uses, exemptions, and insufficient management of threats on freehold land while government programs on Crown Land contributed most to gaining habitat hectares.

Biodiversity 2037, in partnership with several organisations, achieved a number of in-situ conservation activities (as of 2020):

- 865,328 hectares of sustained pest predator control in priority locations
- 888,328 hectares of sustained introduced herbivore control in priority locations
- 201,857 hectares of sustained weed control in priority locations
- 74 hectares of revegetation for habitat connectivity in priority locations since 2017

There have been significant changes to the harvest systems used by VicForests. Since July 2019, VicForests have been using variable retention harvesting in a majority of coupes. Since 2019-20, VicForests harvested 3,281 hectares of native timber using this technique. According to their post-harvest monitoring program, variable retention harvesting was found to be better in protecting wildlife as species are found to persist within and around the completed harvest areas.[1331] Importantly, this result was based on five years of data suggesting that long-term monitoring data is required in order to accurately identify if species persist within coupes subject to this treatment. Other research further supports the approach's environmental benefits of this approach for certain groups of small mammals, birds, and vascular plants.[1332] However, this research also suggested that variable retention harvesting will still erode broader ecological and economic contextual issues, such as water yields. Nevertheless, this is an important example of active adaptive management of forests and an improvement of harvesting regimes compared to previously used harvesting methods. Victorian Government's announcement on bringing forward the end of native forest logging to January 2024 will result in minimising environmental impact of native timber harvesting.

Ex-situ conservation effort

Much of the conservation of threatened forest-dependent species has focused on in-situ approaches, such as revegetation, mitigating threatening processes and management of habitat. Recently, ex-situ conservation efforts have become more important to preventing species extinction due to the rapidly changing environment, including fire regimes.

A typical ex-situ conservation effort is seed banking. Seed banking stores seeds to preserve genetic diversity and are used for restoration and translocation. Nationally, a total of 930 species, or 67.7% of nationally listed threatened flora species, are currently represented in Australia's ex-situ conservation seed banks.[1333]

[1328] Department of Environment, Land, Water and Planning (DELWP) 2023, 'Protecting Victoria's environment - Biodiversity 2037', Melbourne, Victoria, https://www.environment.vic.gov.au/biodiversity/biodiversity-plan Accessed 19 April 2023.

[1329] This figure includes habitats at marine, terrestrial and waterway areas.

[1330] Department of Energy, Environment and Climate Action (DEECA), 'Monitoring trends in biodiversity', https://www.environment.vic.gov.au/biodiversity/monitoring-trends-in-biodiversity Accessed 13 September 2022.

[1331] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

[1332] Lindenmayer D, Blair D, McBurney L 2019, 'Variable retention harvesting in Victoria's Mountain Ash *(Eucalyptus regnans)* forests (southeastern Australia), *Ecological Processes*, 8(2), https://ecologicalprocesses.springeropen.com/articles/10.1186/s13717-018-0156-2 Accessed 14 September 2022.

[1333] Commonwealth of Australia 2021, 'Australia state of the environment - Management approaches', https://soe.dcceew.gov.au/biodiversity/management/management-approaches Accessed 14 September 2022.

Forests

In Victoria, the Victorian Conservation Seedbank is Victoria's primary facility for the conservation of the state's most threatened plants and currently holds over 2,160 collections of seed covering 1,480 taxa, including approximately half of the state's listed species.[1334] There is also a proposed project to establish a spore bank of all fern species in Victoria, as well as selected bryophytes and fungi.[1335] In response to the 2019-20 bushfires, seeds and the cuttings of 120 plant species were collected from within the fire extent, including the Cobungra wattle (Acacia ureniae), mountain celery (Aciphylla glacialis), royal bluebell (Wahlenbergia gloriosa), carpet sedge (Carex jackiana), alpine pepper (Tasmannia xerophila subsp. xerophila), alpine ash (Eucalyptus delegatensis) and spinning gum (Eucalyptus perriniana).[1336]

Ex-situ conservation of threatened species in zoos or aquariums has also risen significantly due to recent disturbances, such as 2019-20 bushfires. Zoos Victoria runs the Fighting Extinction conservation breeding programs for 27 locally threatened species (predominantly terrestrial vertebrate fauna) as a part of their Wildlife Conservation Master Plan 2019-24.[1337] In 2020-21, 19 of the 27 Fighting Extinction species were those that had been impacted by the 2019-20 bushfires. The zoo's 2020-21 animal inventory report showed that the Fighting Extinction program released five threatened forest-dependent species into protected habitat to help re-establish and bolster wild populations and seven threatened forest-dependent species went in captivity (Table Fo13).[1338]

Table Fo13: Number and destination of forest-dependent species that were in captivity and released during 2021.[1339]

Species	Captivity/Release	Number	Destination
Amphibians			
Giant burrowing frog	Captivity	158	Melbourne Zoo
Baw Baw Frog	Release	350	Mount Baw Baw
Spotted tree frog	Captivity	28	Healesville Sanctuary
Birds			
Eastern bristlebird	Captivity	15	Melbourne Zoo
Eastern Bristlebird	Release	8	Croajingalong National Park (Howe Flat)
Helmeted honeyeater	Captivity	1	Healesville Sanctuary
Helmeted honeyeater	Release	60	Yellingbo Nature Conservation Reserve
Helmeted honeyeater	Release	32	O'Shannassay
Yellow-tufted honeyeater	Release	2	Yellingbo Nature Conservation Reserve
Yellow-tufted honeyeater	Captivity	8	Healesville Sanctuary
Mammals			
Leadbeater's possum	Captivity	19	Healesville Sanctuary
Leadbeater's possum	Release	7	Mount Donna Buang (highland)
Leadbeater's possum	Release	11	Wallaby Creek
Leadbeater's possum	Release	4	Yellingbo Nature Conservation Reserve
Reptiles			
Guthega skink	Captivity	5	Healesville Sanctuary

[1334] State Wide Integrated Flora and Fauna Teams (SWIFFT) 2021, 'SWIFFT Seminar Notes 29 July 2021 - Royal Botanic Gardens', https://www.swifft.net.au/cb_pages/swifft_seminar_notes_-_royal_botanic_gardens.php#seedbank Accessed 20 April 2023.

[1335] Ibid.

[1336] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victoria's bushfire emergency: Biodiversity response and recovery- Version 2', Melbourne, Victoria, https://www.wildlife.vic.gov.au/__data/assets/pdf_file/0030/484743/Victorias-bushfire-emergency-Biodiversity-response-and-recovery-Version-2-1.pdf Accessed 20 April 2023.

[1337] More information on the 27 species can be found at https://www.zoo.org.au/fighting-extinction/local-threatened-species/ Accessed 20 April 2023.

[1338] Zoos Victoria 2021, 'Animal Inventory', https://www.zoo.org.au/media/5358/inventory-report-2020212.pdf Accessed 14 September 2022.

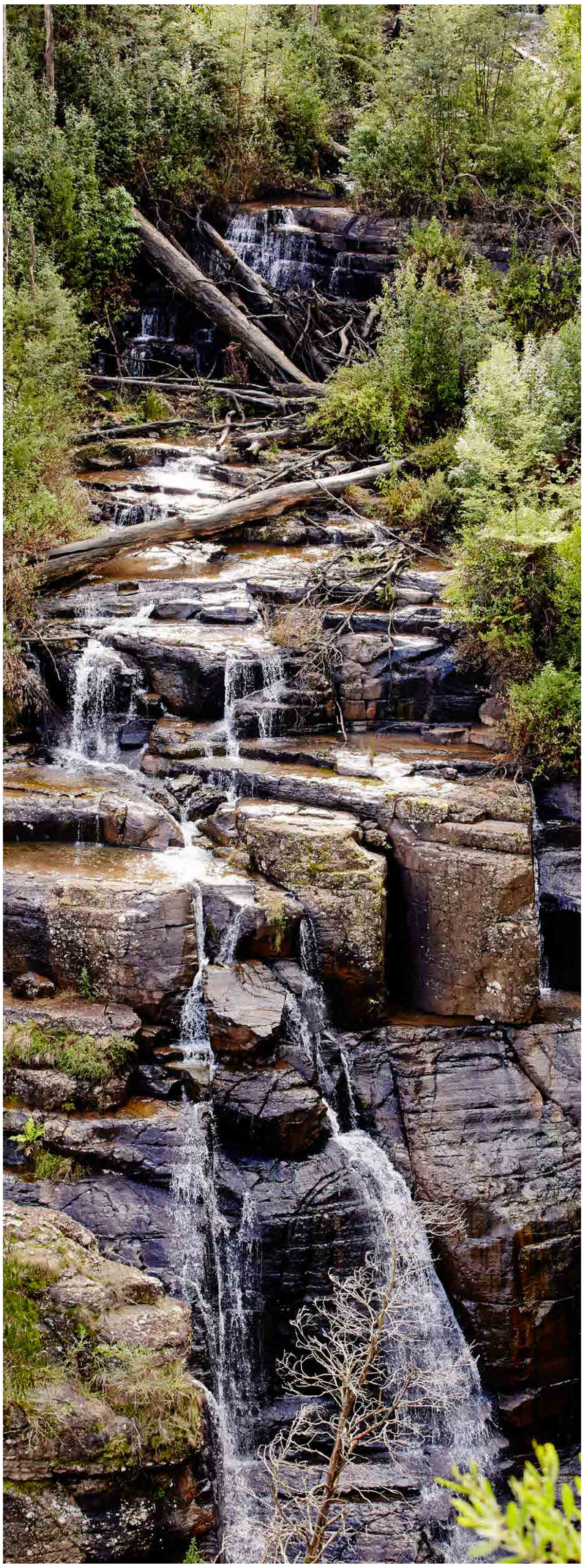
[1339] Ibid.

The Victorian Government allocated significant in-situ and ex-situ efforts to tackle biodiversity decline in Victoria. However, conservation status of VEAC's forest-dependent species has been worsened, and some species were critically impacted, by the 2019-20 bushfires. Despite Government and stakeholders investing into more ecological management of native timber harvesting and increasing the extent of native vegetation areas, invasive species management and captive breeding programs, the deterioration in conservation status of forest-dependent species requires a status assessment of poor. This suggests that more investment on conservation effort may need to be allocated. One example at the national scale is the Federal funding of $225 million to arrest the decline of 110 species and 20 places, such as the Australian Alps. Using USA's success on species recovery, research estimated that Australia would need around $1.7 billion per year for conserving wildlife.[1340] Furthermore, while conservation programs have been progressing for forest-dependent species, it is still unclear what the program's impact on conservation status of forest-dependent species is, thus, the trend for this indicator is assessed as unclear.

Species diversity

A key objective for the conservation of biological diversity is minimising the rate of population decline. Changes in population levels and distribution of species may also provide an early warning of ecosystem stability and resilience.

This report has two relevant indicators for this sub-theme which showed that there was a decline in the status of key forest-dependent species and an increased risk of invasive species on native forest species as a result of 2019-20 bushfires.



Kinglake National Park.
Credit: James Geer.
© Parks Victoria.

[1340] Wintle, BA, Cadenhead, NCR, Morgain, RA, Sarah ML, Sarah AB, Matthew CMA, Hugh PP, James EMW, Martine M, David AK, Stephen TG, John CZW, David BL 2019, 'Spending to save: What will it cost to halt Australia's extinction crisis?' *Conservation Letters*. 12, pp. e12682, https://doi.org/10.1111/conl.12682 Accessed 20 April 2023.

Indicator Fo:06 The status of forest-dependant species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment

Fo:06 The status of forest-dependent species at risk of not maintaining viable breeding populations, as determined by legislation or scientific assessment

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴	↙	🟢	🟡	↙	🟢
Data source(s):	DELWP					
Measure(s):	Number, abundance and distribution of threatened forest-dependent species					

Why this indicator?

This indicator describes the status of known forest-dependent species in Victoria and provides information to improve their conservation status and formal designation.

Why this assessment in 2023?

The conservation status of 75 species of VEAC's 84 threatened forest-dependent species is threatened (critically endangered, endangered or vulnerable) under the FFG Act. As a result of the 2019–20 bushfires, 22 forest-dependent species of VEAC's threatened forest-dependent species were identified to be of most concern, because proportions of their modelled habitat were within the fire extent or affected by high-severity fires. The Victorian Government has applied protection measures applied to those species that were impacted by 2019–20 bushfires and have potential to be impacted by forestry operations. However, the impact of the 2019–20 bushfires has been severe for many forest-dependent species in Victoria, leading to the degradation of their conservation status.

DELWP's prompt response to the 2019–20 bushfires to identify their impact on forest-dependent species, combined with findings from the Major Event Review of the impact on RFAs, and the SoE Biodiversity Update Report, provided sufficient data to assess this indicator.

Summary of State of the Environment 2018 Report assessment

- Since 2013, the only species group having its conservation status updated is vascular plants, which was done in 2014. However, assessing changes in DELWP's advisory list related to plants can be misleading due to the frequent changes in botanical nomenclature.
- Except for the 36 species that were added, the status of the other 461 species has not been changed. Vascular plants represent by far the greatest proportion of these species. This might be due to greater knowledge and awareness of vascular plants within the scientific community, and their relative ease of detection.
- Since 2007–08, no changes have been observed in the number of rare or threatened amphibians.

Critical data used for the 2023 assessment

- Major Event Review of the 2019-20 Bushfires
- State of the Environment Biodiversity Update Report
- RFA Threatened Species and Communities Risk Assessment reports

2023 assessment

The SoE Biodiversity Update Report assessed the conservation status of the 84 VEAC threatened forest-dependent species, including the impact of timber harvesting activities on their number, abundance and distribution. Of the 84 species forest-dependent species, 75 are listed on the FFG Threatened List (see Table 79 in SoE Biodiversity Update report) with some impacted by the 2019-20 bushfires to varying degrees. DELWP's August 2020 report on the bushfires, along with the biodiversity response and recovery, identified the species of most concern, which are having proportions of their modelled habitat within the fire extent or affected by high-severity fires.[1341] A comparison of DEECA's species of most concern with VEAC's forest-dependent species list reveals that those species of most concern were:

- 10 of 15 mammal species
- four of 15 listed bird species
- five of eight listed frog species
- four of five listed reptile species
- three of nine listed fish species
- none of one listed spiny crayfish species
- six of 22 listed plant species.

The Victorian Government completed a risk assessment for threatened species and communities potentially affected by forestry operations across five RFA regions as a part of the modernisation of the Victorian RFAs. In 2020, risks were assessed for 70 species and nine ecological communities (Tranche 1 Risk Assessment). Some threatened species and communities included in the assessment were the Leadbeater's possum, southern greater glider, large forest owls, long-footed potoroo, giant burrowing frog, cool temperate rainforest and aquatic species.

The identified hazards identified through the risk assessment were:

- pest plants and animals
- inappropriate fire regimes
- climate change
- forestry operations
- bushfire management
- roads and strategic fuel breaks
- other (e.g. disease, recreation, pollution).

The process identified interim measures (interim enforceable protections) to protect threatened species and communities from hazards posing significant or high risks in the short-term following the 2019-20 bushfires. Most interim measures were targeted within fire-affected regions, ensuring species and communities impacted by bushfire were supported during their recovery. Species and communities were prioritised for interim action through spatial analysis, literature review, interviews with experts, and updates from scientists conducting field reconnaissance after the 2019-20 bushfires. This prioritisation identified 32 species and communities at the greatest risk of serious, or irreversible, environmental damage in the short term.

The next stage of the Tranche 1 risk assessment process involved assessing the requirement for permanent protections. In September 2022, permanent protections were finalised for 20 species and two communities. These species and communities were identified through spatial analysis, literature review and expert elicitation.

The Victorian RFAs use the new terminology 'listed species and communities'. This is defined as species, taxa or communities listed under Part 13 of the *Environment Protection and Biodiversity Conservation Act 1999* or Part 3 of the FFG Act that are, or have the potential to be, impacted by forestry operations. The Victorian Government's first step to protect listed species and communities was to identify the species which are relevant to the definition in RFAs. The Independent Panel of Major Event Review of 2019-20 bushfires indicated that there are various provisions under the RFAs for listed species and communities where a link to exposure to forest operations is not relevant.[1342]

[1341] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victoria's bushfire emergency: Biodiversity response and recovery- Version 2', Melbourne, Victoria, https://www.wildlife.vic.gov.au/__data/assets/pdf_file/0030/484743/Victorias-bushfire-emergency-Biodiversity-response-and-recovery-Version-2-1.pdf Accessed 20 April 2023.

[1342] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

Under its forest management system, Victoria is required to use its best endeavours to protect important populations, sufficient current and future habitat in the CAR reserve system and to maintain or restore ecological management regimes to ensure their viability. Therefore, the Panel recommended to 'consider the impacts of the major event on listed species and communities across all land tenures regardless of the potential impact from forestry operations' (Recommendation 36 v.).

Between 2018 and 2023, the event that caused the greatest impact on species and communities was the 2019-20 bushfires. The Independent Panel reported that as a result of the bushfires, 46 species out of 70 listed species included in the Tranche 1 Risk Assessment were within the fire extent.[1343] Of these, 15 species had more than 50% of their extent burnt and the following listed species were exposed to high-severity fires across more than 50% of their overall extent: roundsnout Galaxias, East Gippsland galaxias, Betka bottlebrush, Mallacoota burrowing crayfish, Orbost spiny crayfish and eastern she-oak skink. Another two listed species, the diamond python and Watson's tree frog, have had at least 50% of their habitat impacted by multiple high-severity fires since 2000. Four out of nine listed communities were impacted by the 2019–20 bushfires, with the warm temperate rainforest community suffering the greatest impact.[1344] The Alpine sphagnum bogs and associated fens community has had about one-quarter of its extent impacted by multiple fires since 2000, including the 2019–20 bushfires.

The Independent Panel for the Major Event Review report identified that:

> For 35 of the 1,994 FFG Act listed species, including 21 species listed as critically endangered, there is no data available within the biodiversity databases that would enable assessments to be undertaken to identify potential impacts associated with the 2019–20 bushfires. The Panel's analysis suggests that the distribution of seven of these critically endangered species potentially occur within the extent of the 2019–20 bushfires and would therefore benefit from early effort to update distribution information and assess any impacts from these bushfires.' [1345]

The Panel also found that the application of the precautionary principle and tailored adaptive responses in fire-affected areas is a sound approach to mitigate the risk of serious or irreversible damage from timber harvesting. However, in 2022, the Panel recommended to include an assessment of outcomes of the action plans for the 32 prioritised species and communities for introducing permanent protections.

In mid-2021, DELWP completed the risk assessments for the platypus and little eagle. Based on the findings of these risk assessments, there was no requirement for interim protections to manage risks from forestry operations for either species in the short-term. Tranche 2 Risk Assessments of 61 newly listed threatened species under the FFG Act were completed in September 2022.[1346] The assessments identified 32 species to be at significant or high risk from forestry operations. Among the 32 species, nine species were related to plantations and 23 species were related to native forestry operations. Some 19 species were identified to require interim protections relating to forestry operations, including three species of spiny crayfish, seven rainforest affiliated species, and nine restricted and limited range plant species. These protections will be complemented by an assessment of the requirement for permanent protections for any of the 61 species in 2023.

[1343] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

[1344] Ibid.

[1345] Ibid.

[1346] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Threatened species and communities risk assessment - tranche 2 risk assessment and interim protections', Melbourne, Victoria, https://www.environment.vic.gov.au/__data/assets/pdf_file/0031/595039/Tranche-2-Risk-Assessment-and-Interim-Protections-Report-September-2022.pdf Accessed 20 December 2022.

Following the implementation of any permanent protections, new or updated action statements will be prepared for all species and communities subject to risk assessments, as required under the FFG Act. More detailed management plans will also be prepared for some species and communities. These action statements and management plans will be based on a detailed assessment of the management actions necessary for the conservation of each species and community. All hazards, as well as all relevant social and economic factors, will be considered in their preparation. Stakeholder consultation during the development of the action statements will help to ensure proposed management actions are feasible and proportionate. Other than Government's effort to conserve and protect forest-dependent species from forestry operations, it is also important to understand the life history of those species for making sound management decisions and valid scientific conclusions. Presence or absence of a species from a collection of landscape units is a widely used concept for wildlife management.[1347] Use of presence/absence records for assessing population condition, and potential deterioration, could be misleading in certain circumstances unless repeated surveys within a relatively short timeframe are delivered.[1348] In Victoria, most existing data relates to presence/absence records of species rather than detailed information regarding key life history processes, such as recruitment and mortality rates, abundance and measures of genetic diversity. A more holistic approach in assessing population condition for forest-dependent species is required to better understand the species and achieve conservation outcomes.

Great Otway National Park.
Credit: Christian Pearson.
© Parks Victoria.

[1347] MacKenzie DI 2005, 'What are the issues with presence-absence data for wildlife managers?', *Journal of Wildlife Management*, 69(3), pp. 849–60, http://www.jstor.org/stable/3803327. Accessed 19 December 2022.

[1348] Ibid.

Forests

Indicator Fo:07 Degree of disturbance to native forest species caused by invasive species

Fo:07 Degree of disturbance to native forest species caused by invasive species

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	?	🟡	🟡	↙	🟢

Data source(s):	DELWP
Measure(s):	Status of environmental weeds Government's works to mitigate disturbance by invasive species Status of deer abundance and distribution

Why this indicator?

Invasive species are one of the major threats to Victoria's biodiversity. In forest ecosystems, the threats caused by invasive species include species competition, transmission of diseases and soil degradation. This indicator assesses the current state of disturbance caused by invasive species and how their impact has changed with future estimations.

Why this assessment in 2023?

As well as reducing native wildlife populations, the 2019–20 bushfires reduced populations of feral cats and foxes. However, the removal of refugia, such as shrubs, grass cover and hollow logs, as a result of the bushfires promoted higher levels of predation by these invasive animals on native wildlife. To tackle this issue, the Victorian Government invested in implementing invasive species control activities, including aerial shooting. However, given that there is uncertainty about the effectiveness of the Government's efforts in controlling invasive species to protect native forest-dependent species, the status is rated as fair.

The Government has a strategy for controlling invasive species that includes research on the abundance and distribution of deer species and investment in weed management and aerial shooting. However, the discontinuation of data (impact and distribution of weeds, insects and pathogens) that were included in the SoE 2018 Report has resulted in a trend assessment in 2023 of 'unclear'.

There is sufficient information on the status of invasive species and on the Government's management response to tackle invasive species. However, estimations of the abundance and distribution of deer species are needed in order to identify the impact of government response activities, like aerial shooting and weed removal.

Summary of State of the Environment 2018 Report assessment

- The data shows that the proportion of weed species to total species is highest in the New South Wales Southwestern Slopes bioregion (24%) and the Riverina bioregion (20%).
- For most identified pathogens and insect agents in Victoria, damage during the reporting period has stabilised or decreased. But a few species, including the red gum basket lerp, Dothistroma needle blight, Mycosphaerella leaf disease, cypress canker and *Phytophthora cinnamomi* have expanded their distribution and impact.

Critical data used for the 2023 assessment

- Progress in Bushfire Biodiversity Response and Recovery (BBRR) program
- Progress in the Weeds and Pests on Public Land program
- Change in advisory list of environmental weeds in Victoria
- Estimation of economic cost of deer impact on the broader Victorian community

2023 assessment

Invasive species are any species that are non-native to a particular Victorian ecosystem, and whose introduction and spread causes adverse sociocultural, economic and/or environmental impact. As invasive species often do not have natural predators in the ecosystems in which they have become introduced, they can spread, reproduce and out-compete compete native species for habitat at a relatively higher rate, causing severe ecological degradation. Understanding the degree of disturbance caused by invasive species can provide an indication of the effectiveness of management and control actions and assist with the evaluation of policy responses. The most significant disturbance that caused an increased threat of invasive species in Victorian forests was the 2019-20 bushfires. Large herbivores, such as deer and feral goats, can quickly move into new areas after a fire and seriously damage vegetation by preventing successful regrowth of native plants following the fire and introduce weeds. The 2019-20 bushfires reduced population of feral cats and foxes just like native animals. However, the removal of refuges, such as shrubs, grass cover and hollow logs, as a result of the bushfires acted in promoting these invasive animals to become more efficient predators of native wildlife.

In response to the 2019-20 bushfires, the Victorian Government allocated $25 million towards threat management as a part of the BBRR program ('intensified and sustained management of threat' section). This program is to reduce the impact of introduced animals and weeds on the survival and recovery of threatened species in fire-affected areas. Some key actions include aerial shooting of introduced pest animals on public land, targeted ground control of introduced pest animals and targeted weed control. Additionally, the Australian Government's Regional Fund for Wildlife and Habitat Bushfire Recovery also provided funding of $6.2 million. Support for landscape-scale weed and pest projects was also provided through the Weeds and Pests on Public Land program as well as $1 million from PV each year.

The BBRR program achieved 17,000 hectares of weed management as of 2022. Additionally, the advisory list of environmental weeds in Victoria has been updated as part of this program. This list provides general advice to conservation managers on the relative risks posed by different environmental weeds and the relative urgency of managing them across Victoria's natural ecosystems.[1349] There is now a total of over 1,800 taxa on the updated list, including 34 species new to the list since 2018 (Table Fo14).

Table Fo14: Changes to the advisory list of environmental weeds in Victoria from 2018 to 2022.[1350]

Advisory list of environmental weeds in Victoria	2018 number	2022 number
Environmental weeds	1235	1251
Species that are native to Victoria but have become naturalised well beyond their pre-European distribution	49	52
Species that have been previously naturalised but are not considered to be extinct in the wild	113	113
Species currently considered to be casual or ruderal in Victoria	-	360
Species that are likely to become environmental weeds in Victoria in the future	82	86
Vascular and non-vascular plant species	1786*	1810*

**Note:* *These figures are based on the number of species that are listed under the Advisory list in 2022. The list includes species that are native to Victoria but have become naturalised well beyond their pre-European distribution' as environmental weeds.*

[1349] White M, Cheal D, Carr GW, Adair R, Blood K, Muir A, Meagher D 2022, 'Advisory list of environmental weeds in Victoria 2022', Heidelberg, Victoria, https://www.environment.vic.gov.au/__data/assets/excel_doc/0027/563607/Advisory-list-of-environmental-weeds-in-Victoria_2022.xlsx Accessed 12 August 2022.

[1350] Ibid.

The government estimates that aerial shooting activities resulted in an improvement of the likelihood of future survival for 22 animal and 72 plant species most at risk after the 2019-20 bushfires, including the brush-tailed rock wallaby, alpine water skink, and eastern bristlebird.[1351] However, this does not indicate that the long-term viability of these species has not been improved by aerial shooting post-fire. Instead, the aerial shooting activities could reduce impacts from invasive species, including deer on habitat recovery following fire. The Arthur Rylah Institute (ARI) analysed data from aerial shooting operations in eastern Victoria between February 2020 and May 2021 to determine the effectiveness of aerial control of deer. The analysis indicates that the aerial shooting operations resulted in significant reduction of Sambar deer population for some national parks, including Mount Buffalo National Park and Snowy River National Park. Their final report on this analysis will be released in 2023.

There has been growing concern regarding increasing deer population (mostly sambar deer), but it is unclear how the government's current effort, including aerial shooting, is sufficient to reduce the population of deer in the state. The 2020-21 State Budget provided $4.4 million per year for the development and implementation of regional deer control plans under the Victorian Deer Control Strategy for four years. It is unclear whether current funding would be sufficient to reduce impacts on priority values. ARI has been undertaking a research project under the Victorian Deer Control Program, which includes an assessment of the abundance and distribution of the major deer species at sub-regional, regional, and statewide scales. This will enable the government to assess trends in the distribution and population of deer populations, which could lead to strategic management of deer species for protection of priority areas

The Invasive Species Council reported that there could be upwards of 1.7 to 4.6 million deer by 2050 in Victoria if no significant management action is taken.[1352] The report also indicated the cost arising from deer to the broader community could be up to $2.2 billion over the next 30 years. Among this cost, it is estimated that $269 million to $365 million in economic costs will be incurred from lost forestry production in plantations due to deer grazing and trampling. Additionally, it is estimated that there will be a further $308 million to $474 million in social costs from reduced recreation and use of Victorian national and state parks due to the impact of deer. This report indicates the importance of the Government's control plans to the industries that rely on native forest.

As there has been discontinuation of the 2018 data, there could be no assessment of the trend in disturbance to native forest species in Victoria. Based on the uncertainty of the effectiveness of the government's effort to tackle invasive species to protect native forest species, which includes introduced herbivore control across 680,000 hectares, the current status for this indicator is listed as fair.

Ecosystem health

A decline in forest ecosystem health and vitality may have significant economic, social and ecological consequences for Victorian community, including a loss of forest benefits and the degradation of environmental quality. Monitoring and maintenance of forest ecosystem health is the foundation of sustainable forest management. Indicators under this sub-theme focus on the impact of natural and human-induced disturbances on forest health and vitality. Disturbances include fire, climatic events, planned burning and road management.

[1351] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Managing invasive species after fire', https://www.environment.vic.gov.au/invasive-plants-and-animals/managing-invasive-species-after-fire?_ga=2.105658816.279746837.1660276966-419823010.1651546729 Accessed 20 April 2023.

[1352] Invasive Species Council 2022, 'Counting the doe: an analysis of the economic, social and environmental cost of feral deer in Victoria' https://invasives.org.au/wp-content/uploads/2022/06/Counting-the-doe-the-economic-impacts-of-feral-deer-in-Victoria.pdf Accessed 12 August 2022.

Forests

Indicator Fo:08A Scale and impact of agents and processes affecting forest health and vitality - mortality, dieback, canopy health

Fo:08A Scale and impact of agents and processes affecting forest health and vitality – mortality, dieback, canopy health

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	?	🟡	🟡	?	🟡
Data source(s):	DELWP					
Measure(s):	Degree of leaf damage based on mortality, crown dieback and crown defoliation					

Why this indicator?

Forest health and vitality are related to a number of natural disturbances that are strongly influenced by climate. In Victoria, natural disturbances can include fire, non-native species invasions, floods, disease outbreaks and climatic events, such as windstorms, extreme temperatures and millennial drought events. These events influence the composition, structure and functions of forests.

The effects of such disturbances, however, are not always negative. Rather, they can be an important part of natural processes essential to the long-term health of ecosystems. Forests have evolved to survive and regenerate from certain natural disturbances. However, recently there have been major shifts in the frequency, scale and intensity of agents and processes that can cause significant disruptions in forest ecosystems, resulting in a dramatic increase in the susceptibility of forest health and vitality. Capturing these shifts through monitoring programs is vital, as predictions indicate that forest ecosystems will be increasingly exposed to these events due to climate change.

Why this assessment in 2023?

There are insufficient data to determine the current status and trend of forest health and vitality. Assessing the status and trend of tree mortality, dieback and canopy health indices is not possible due to lack of comprehensive analyses that use information on the occurrence of processes or agents impacting on forest ecosystem health and vitality, including fire, climatic events, grazing, pathogens, weeds, pests and land clearing.

Summary of State of the Environment 2018 Report assessment

- The robustness of previous datasets is weaker than the 2018 dataset, preventing comparison of current and past data.
- Across all Victorian bioregions, the average percentage of areas showing mortality, crown dieback and impacted canopy health are 14.3%, 20.3% and 23.3%, respectively.

Critical data used for the 2023 assessment

- New data were unavailable for this indicator

2023 assessment

Forest health and vitality are critically related to a variety of natural disturbances, which are strongly influenced by climate. In Victoria, natural disturbances can include fire, non-native species invasions, floods, disease outbreaks and climatic events such as windstorms, extreme temperatures and millennial drought events. All of these events influence the composition, structure and function of forests.

The effects of such disturbances are not always negative, rather, they can be an important part of natural processes essential to the long-term health of ecosystems. Forests have evolved to overcome and regenerate from certain natural disturbances. However, there have been major shifts recently in the frequency, scale and intensity of the agents and processes that can cause significant disruptions in forest ecosystems, resulting in a dramatic increase in the susceptibility of forest health and vitality. Capturing these shifts through monitoring programs is vital, as predictions indicate that forest ecosystems will be increasingly exposed to these events due to climate change.[1353]

Condition of the forest canopy is used globally as an indicator of forest health.[1354] This report presents three measures of tree-canopy quality: mortality, crown dieback and canopy health. Mortality is defined as the proportion of the stand basal area (m^2/ha) in dead trees.[1355] Crown dieback is the amount of withered branches within the canopy, often over a certain period and is measured by the VFMP as the proportion of dominant branches in tree crowns lacking living foliage. Canopy health is assessed through the amount of defoliation and discolouration of the crown canopy. This is measured as the percentage of existing foliage over an estimated foliage volume.

Between 2018 and 2023, field assessments of VFMP plots have been restricted due to COVID-19 as well as physical damage on some plots as a result of 2019-20 bushfires. The data collected during targeted survey periods does not provide scientifically robust trend analyses in canopy health as the base data collected in 2018 were from the whole plots. Therefore, the data provided in this report cannot be compared with that of the SoE 2018 Report.

As a result of a wide confidence interval of the mortality rate in every forest tenure, and in each bioregion (Figure Fo12), it is difficult to identify significant differences between bioregions, parks and reserves and state forests. Although, there were differences detected for the Australian Alps, Murray Darling Depression, NSW South Western Slopes and Riverina bioregions where a higher mortality rate was identified within parks and conservation reserves compared to state parks.

On average, the crown dieback by bioregion was between 11% and 25% out of total large-tree basal area (Figure Fo13). Bioregions with more than 20% dieback rate included the Murray Darling Depression, Naracoorte Coastal Plain, South East Coastal Plain and Victorian Volcanic Plain. The eastern parts of Victorian bioregions (South East Corner, South Eastern Highlands and Australian Alps) were found to have lower rates of dieback. When comparing parks and reserves with state forests, the South East Coastal Plain bioregion had the greatest difference, with a proportion of dieback rates in the parks and reserves area being about 60% greater than in state forests. The Riverina bioregion was also found to have a similar pattern. On the other hand, the state forests within the Naracoorte Coastal Plain and Victorian Volcanic Plain bioregions had higher dieback rates than park and conservation reserve by a third. These differing patterns may be due to a range of factors, including different site conditions, management history and current uses.

At the bioregion level, canopy condition was worst affected in the Naracoorte Coastal Plain and the centre of the South Eastern Highlands. Due to a wide confidence interval, bioregions in eastern Victoria had no statistically significant difference between state forests and parks and conservation reserves (Figure Fo14).

Figure Fo15 summarises average canopy health affected for measured plots by bioregion. Plot-derived canopy health data were interpolated across the state using the kriging method in ArcGIS software that is widely used for spatial analytics (Figure Fo15). This method is a geostatistical technique that can predict certain status, in this case canopy health, based on a scattered set of spatial data points from field measurements through the VFMP. This method has been used internationally to estimate forest cover and forest health.[1356, 1357]

The SoE 2018 Report concluded that it would be counterproductive to determine the current status of forest health and vitality in Victoria using tree mortality and dieback rate, as there is no comparative threshold. This is also applicable to this report as comparative analysis is still not available. This highlights the need to detect changes in the condition of Victoria's forests as it could lead to developing strategies and management actions to mitigate deterioration.

[1353] Ian F 2009, 'Fires, forests and futures: The ANU Westoby lecture'. *Australian Forestry*, 72(4), pp. 195-205.

[1354] Stone C, Haywood A 2006, 'Assessing canopy health of native eucalypt forests', *Ecological Management and Restoration*, 7, pp. S24-S30.

[1355] Basal area is the cross-sectional area of a tree's trunk, measured at 1.3 m above the ground.

[1356] Dindaroğlu T 2014, 'The use of the GIS Kriging technique to determine the spatial changes of natural radionuclide concentrations in soil and forest cover', *Journal of Environmental Health Science and Engineering*, 12(1), pp. 130.

[1357] Conkling BL 2011, 'Forest health monitoring: 2007 national technical report'. General Technical Reports SRS-147, Asheville, NC, US Department of Agriculture Forest Service, Southern Research Station, 147, pp. 1-59.

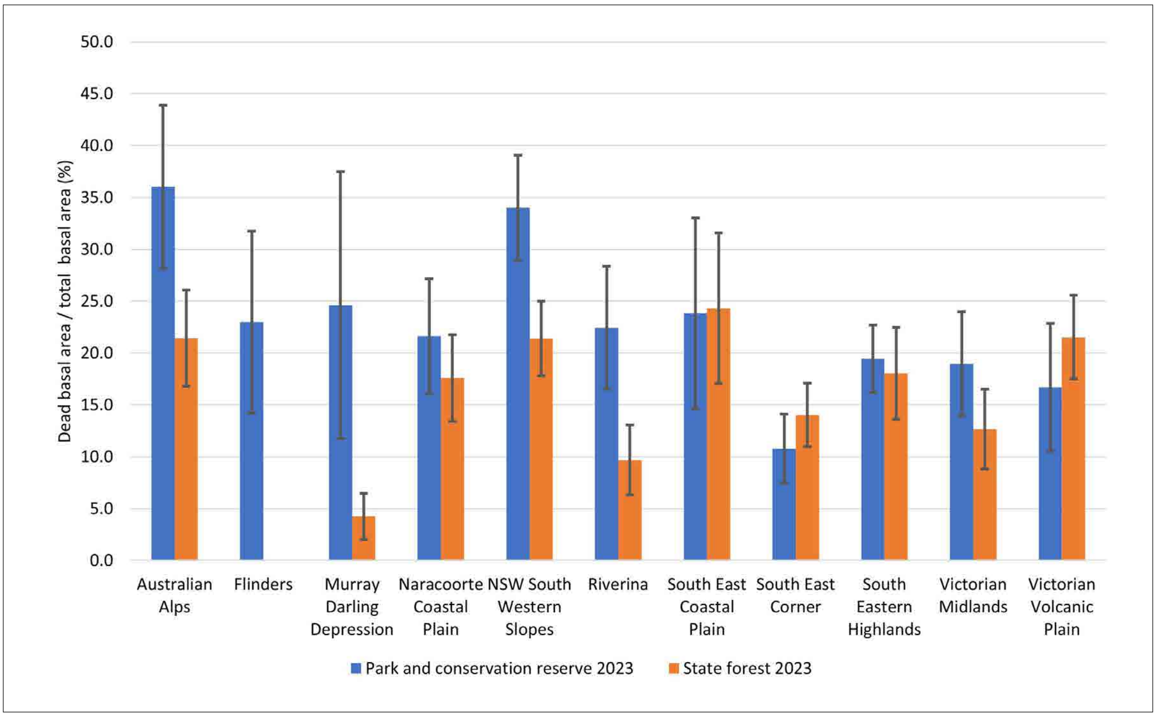


Figure Fo12: Mortality as a proportion of total dead basal area to total live basal area for large trees by bioregion in Victorian parks and conservation reserves and state forests during 2023.[1358]

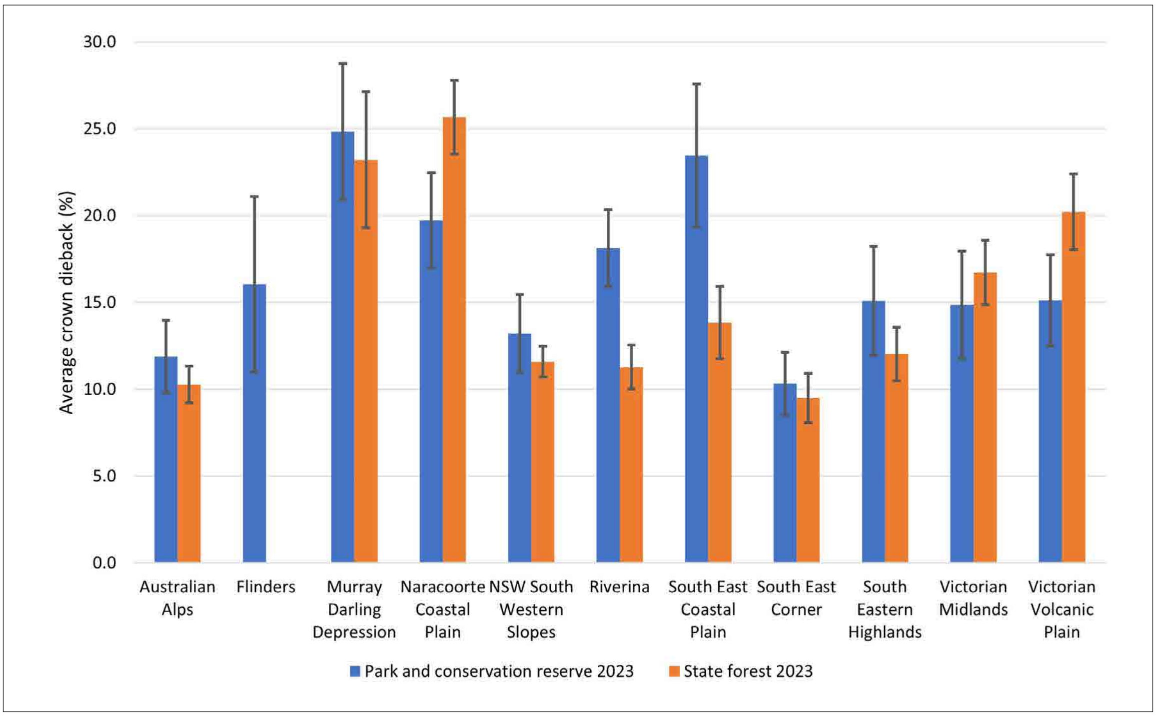


Figure Fo13: Average canopy dieback and defoliation rates within sampling plots by bioregion in Victorian parks and conservation reserves and state forests during 2023.[1359]

1358. Department of Energy, Environment and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.
1359. Ibid.

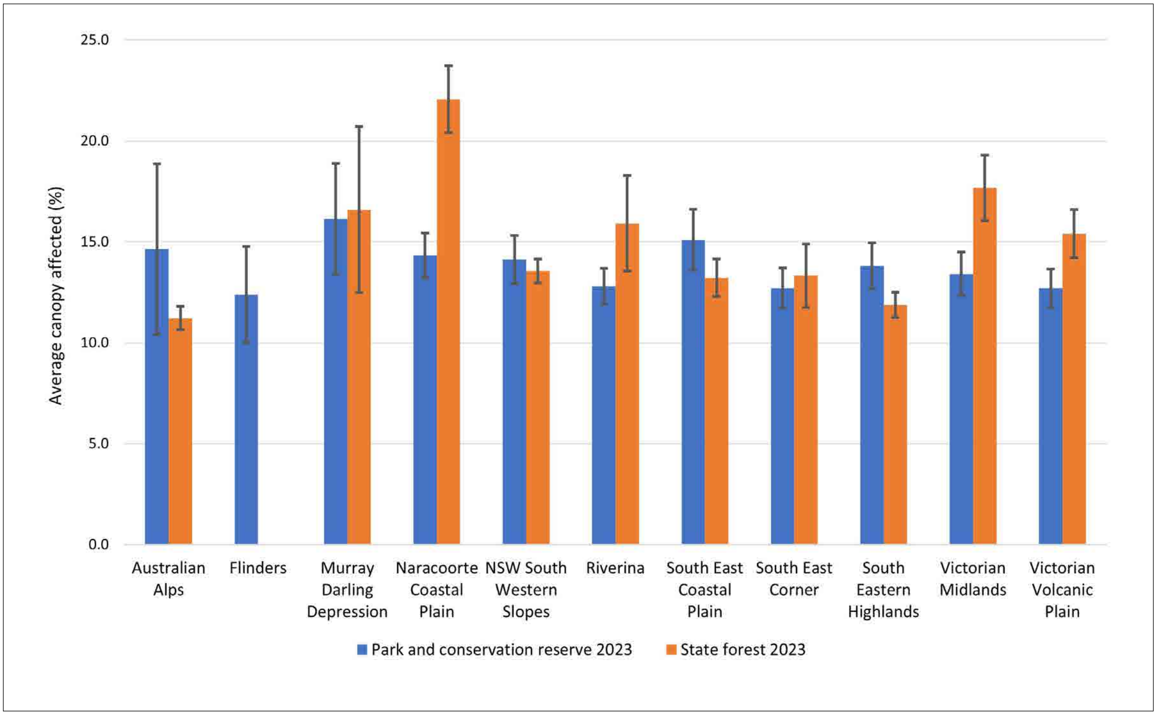


Figure Fo14: Canopy health as characterised through discolouration and defoliation by bioregion in Victorian parks and conservation reserves and state forests during 2023.[1360]

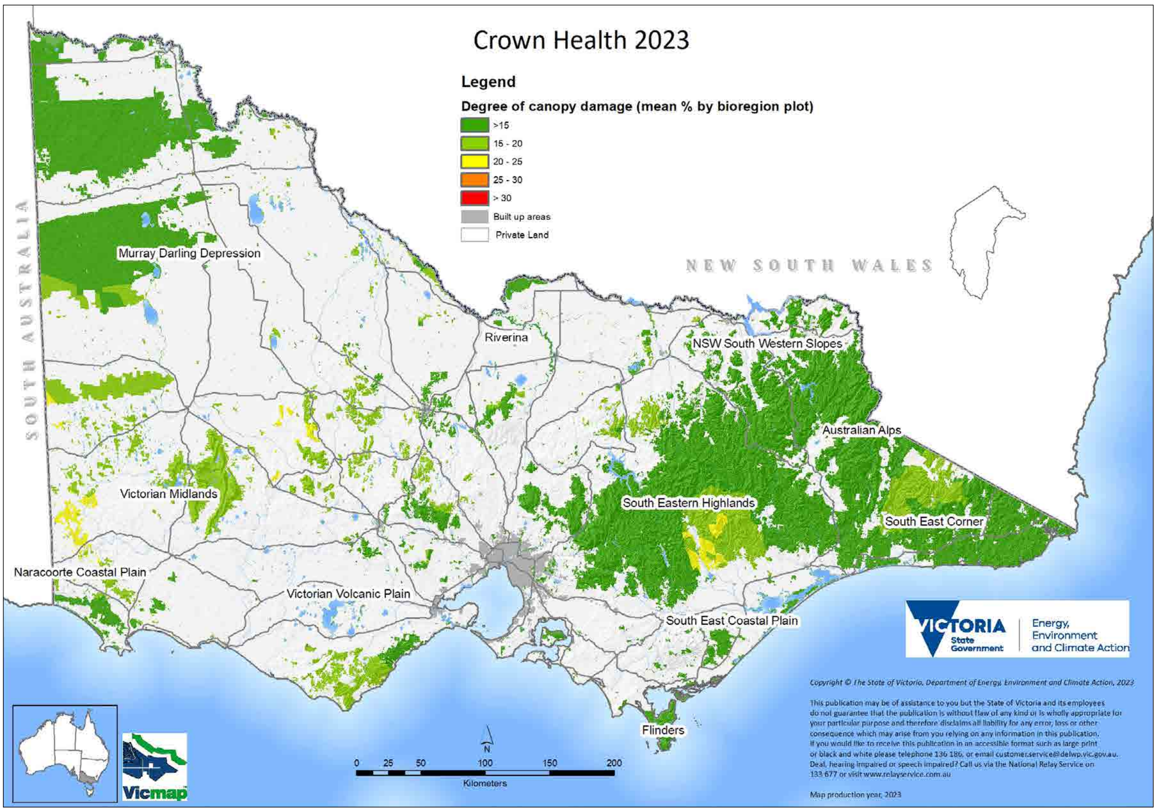


Figure Fo15: Crown health as characterised by defoliation and discolouration in Victoria during 2023.[1361]

[1360] Department of Energy, Environment and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.

[1361] Ibid.

Forests

Indicator Fo:08B Scale and impact of agents and processes affecting forest health and vitality - bushfire-affected area and climate

Fo:08B Scale and impact of agents and processes affecting forest health and vitality – bushfire-affected area and climate

Regions(s)	2023 status	2023 trend	2023 confidence		2018 status	2018 trend	2018 data quality
Statewide	🔴	↙	🟢		🟡	↙	🟢
Data source(s):	DELWP						
Measure(s):	Bushfire-affected area (ha) Annual mean temperature, by year Number of unusually warm days, by year						

Why this indicator?

Victoria's forests are impacted by a range of disturbances, both natural and human-induced. It is important to monitor the impact of major disturbances that could negatively affect the health and vitality of Victoria's forests.

Why this assessment in 2023?

Considering the impact of the 2019–20 bushfires on tolerable fire interval (TFI), it could be estimated that ecosystem resilience has been severely affected. Academic research has identified that even fire-tolerant species altered their composition, making forests more flammable for future fires. Further work to assess and monitor these changes is required.

Bushfire-impacted areas have been increasing. Since 2000, the area exposed to multiple high-severity fires now exceeds 276,000 hectares, and this is expected to continue to increase as Victoria's climate continues to get warmer and drier as a result of climate change. Furthermore, the amount of area burnt while vegetation was below TFI increased significantly as a result of the 2019–20 bushfires. As a result of increased fire frequency and intensity, it is unclear how forests in Victoria would respond to this changed fire regime.

There is sufficient information regarding bushfire impacts and climate, but there is a growing need for information regarding the impact of changed fire regimes on forests.

Summary of State of the Environment 2018 Report assessment

- Between 2013 and 2018, the most damaging bushfire was the Wye River-Jamieson Track fire, ignited by lightning on 19 December 2015. The fire exceeded control lines on Christmas Day under extreme weather conditions, burning 2,520 hectares of national park and private properties, with an estimated 160 houses impacted.
- Between 2013 and 2014, Victoria experienced its most significant fire season since 2008, which challenged emergency services and Victorian communities. Across the season, Victoria had 19 days of severe and extreme fire danger ratings, and 16 days of total fire ban. More than 463,000 hectares of public and private land were burnt, and 80 residences destroyed.
- The extent of bushfire-affected area has been decreasing since 2003. However, annual mean temperature and the number of unusually warm days were increasing, so this declining trend in bushfire-affected area could reverse in the future.
- The Victorian climate has been gradually warming since the 1950s. Since the SoE 2013 Report, every year has been among the top-ten warmest in Victoria on record, with 2014 being the second-warmest year on record (behind 2007).[1362] The temperature increase is observed in both daytime (maximum) and overnight (minimum) temperatures, with the greatest level of warming in summer (0.14 °C increase per decade) and the smallest in winter (0.06 °C increase per decade).

[1362] Bureau of Meteorology (BOM), 'Heatwave service for Australia', Melbourne, Victoria, www.bom.gov.au/australia/heatwave Accessed 20 April 2023.

Forests

Critical data used for the 2023 assessment

- Bushfire affected area
- Annual mean temperature anomaly in Victoria
- Bureau of Meteorology (BOM) data on Victorian average annual rainfall

2023 assessment

Bushfire affected area

The major bushfire event that occurred in Victoria since 2018 was the 2019-20 bushfires, which commenced on 21 November 2019 and comprised of an estimated 60 fires across the state. The last major fire complex in East Gippsland was declared contained three months later, on 27 February 2020. The 2019-20 bushfires burnt more than 1.5 million hectares, including nearly 1.39 million hectares of native forest or 18% of Victoria's public native forests (Figure Fo16).

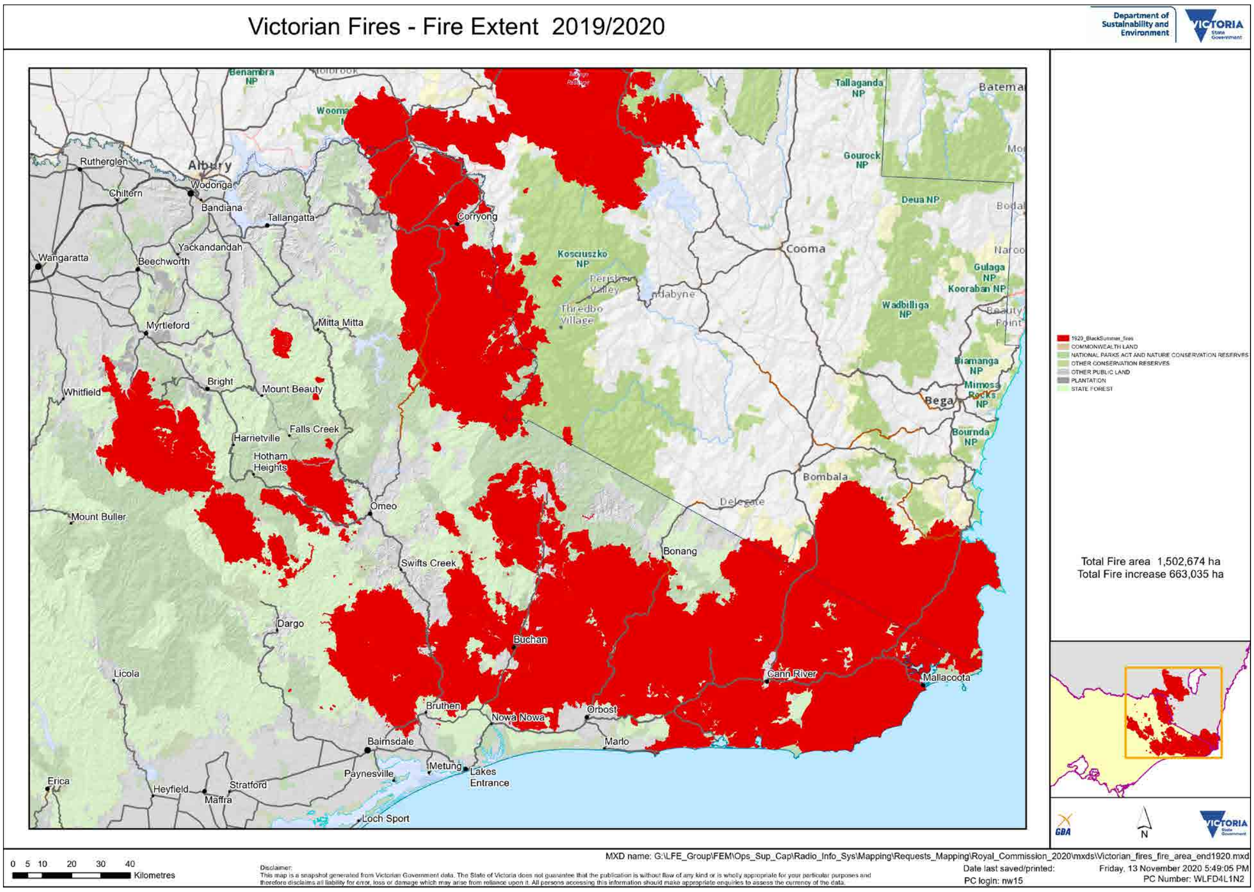


Figure Fo16: Bushfire extent in Victoria during 2019-20.[1363]

The Major Event Review report found that there were 32 EVCs that had over 50% of their modelled extent located within the fire extent across all Victorian RFA regions.[1364] Four of the 32 EVCs had more than 95% of their extent burned. Currently, EVC extent is assumed to be constant regardless of the impacts of extreme, or large-scale, events which could have a major influence on the ecological functions of a forest.

[1363] State Government of Victoria 2020, 'Victorian fires - fire extent 2019/2020', https://www.vic.gov.au/2019-20-eastern-victorian-bushfires Accessed 8 July 2022.

[1364] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

This catastrophic event in 2019-20 resulted in a significant increase of area burnt by bushfires since 2000 (Figure Fo17 and Figure Fo18). Figure Fo18 shows that the bushfires burnt over 1.5 million hectares in Victoria. This is the largest bushfire extent among all bushfires that have occurred since 2000. In addition, the 2019-20 bushfires impacted many areas that have been burnt by fires multiple times since 2000. The Major Event Review report's analyses shows that, over the past 20 years, more than 5% of Victoria's public land has been burnt multiple times by large bushfires, and all of these areas are in the eastern portion of the state. About 276,000 hectares (6.3%) of the public land in eastern Victoria has been burnt multiple times within 20 years. Among the areas impacted by multiple fires, around 14,000 hectares were burnt more than three times.[1365] The bushfires also burnt about 10% of vegetation on public land while below minimum TFI (see Fi:03 for more detail).

However, the total impact of frequent fires on Victoria's forests remains unclear. It is possible that exposure to repeated, high-severity fires could increase tree mortality and cause significantly reduced regeneration capacity of surviving trees. Researchers from the University of Melbourne reviewed the effects of multiple wildfires on tree mortality and regeneration in both obligate seeder and resprouter eucalypt forests in Victoria.[1366] They found that a structural change can occur when high-severity fire occurs more than once within six years. These changes include canopy stems killed by fire being replaced by stems with lower height and an increased stem density, with thinner stems at lower height. They also reported that both historical and recent evidence indicates that recurrent wildfires threaten the persistence of the fire-sensitive obligate seeder eucalypt forests, which can facilitate a shift to non-forest states if successive fires occur within the trees' primary juvenile period (1 to 20 years). Overall, their research highlights the potential for structural and state changes in the fire-tolerant resprouter forests, particularly if recurrent severe wildfires kill seedlings and increase tree mortality. The Major Event Review report recommended that the Victorian and Commonwealth governments commit to a comprehensive, long-term research and monitoring program to develop a better understanding of the impacts of repeated short-interval severe bushfires.

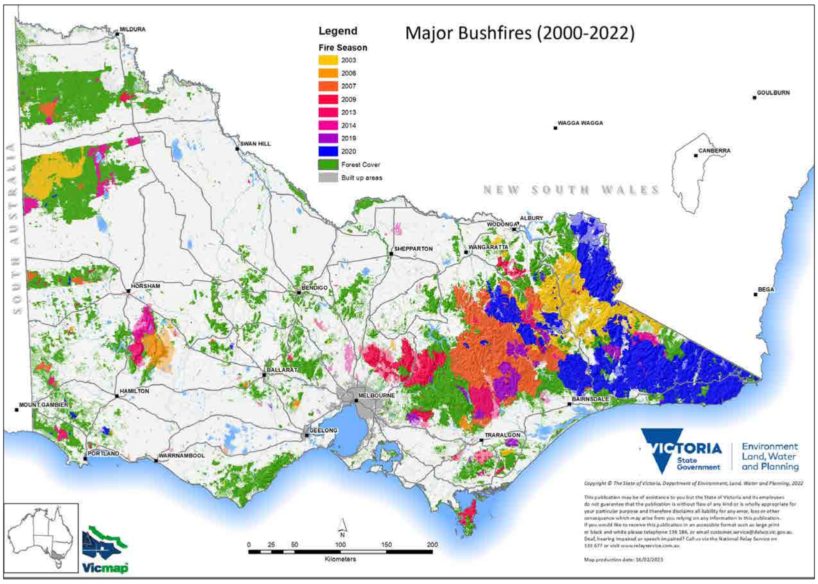


Figure Fo17: Major bushfires in Victoria between 2000 and 2022.[1367]

1365. Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.
1366. Fairman TA, Nitschke CR, Bennett LT 2015, 'Too much, too soon? A review of the effects of increasing wildfire frequency on tree mortality and regeneration in temperate eucalypt forests', *International Journal of Wildland Fire*, 2016, 25, pp. 831-848.
1367. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

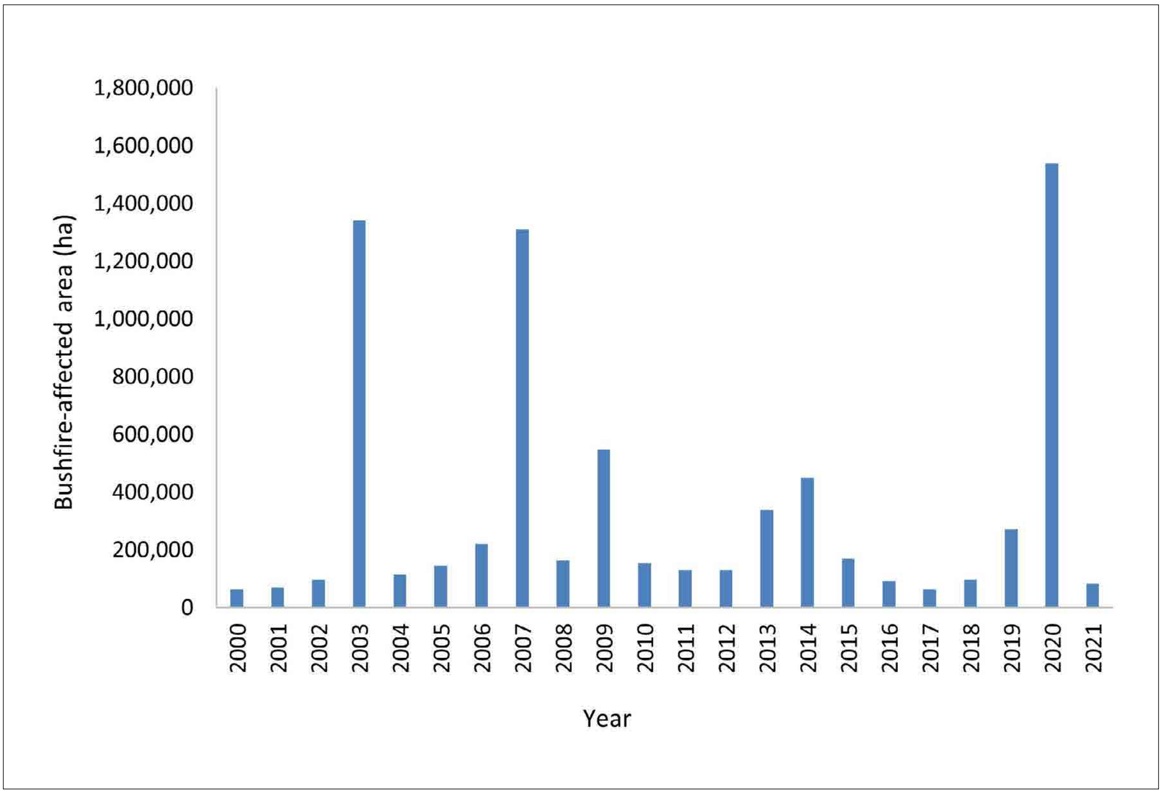


Figure Fo18: Total area affected by bushfires in Victoria between 2000 and 2021.[1368]

Climate

The Victorian climate has been gradually warming. The Victorian Climate Projections indicated that the mean annual temperature rising by just over 1 degree between 1910 and 2018 (Figure Fo19).[1369] Between 1997 and 2021, annual temperature has been higher than mean temperature. This means that for about 25 years there has been no single year that has been lower than the mean temperature. The temperature increase was observed in both daytime (maximum) and overnight (minimum) temperatures, with the greatest degree of warming in summer (0.14°C increase per decade) and the smallest in winter (0.06°C increase per decade). Rainfall in Victoria is highly variability, but there has been a gradual decrease of rainfall since the 1990s (Figure Fo20).

Projections suggest that temperature in Victoria may increase between 1.3 to 4.3°C between the 1990s and 2090s depending on the GHG emissions pathway. In terms of rainfall, Victoria is projected to continue to become drier in the long term in all seasons except during the summer, with large variability in rainfall occurring at scales from days to decades (Figure Fo20). This temperature and rainfall trend will lead to changes in fire weather with considerable year-to-year variability. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) indicates that the frequency of dangerous fire weather days has increased significantly in recent decades in south-eastern Australia.[1370] These increases are particularly evident during spring and summer and are associated with an earlier start to the southern fire weather season.[1371]

1368. Forest Fire Management Victoria 2023, 'Bushfire risk to life and property and ecological values', https://www.ffm.vic.gov.au/fuel-management-report-2020-21/statewide-achievements/bushfire-risk Accessed 18 April 2023.
1369. Clarke JM, Grose M, Thatcher M, Hernaman V, Heady C, Round V, Rafter T, Trenham C, Wilson L. 2019, 'Victorian climate projections 2019 technical report'. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Melbourne, Victoria, https://www.climatechangeinaustralia.gov.au/media/ccia/2.2/cms_page_media/508/Vic%20Climate%20Projections%202019%20Technical%20Report_1.pdf Accessed 8 July 2022.
1370. Bureau of Meteorology (BOM) 2022, 'State of the climate 2022', http://www.bom.gov.au/state-of-the-climate/2022/documents/2022-state-of-the-climate-web.pdf Accessed 24 November 2022.
1371. Ibid.

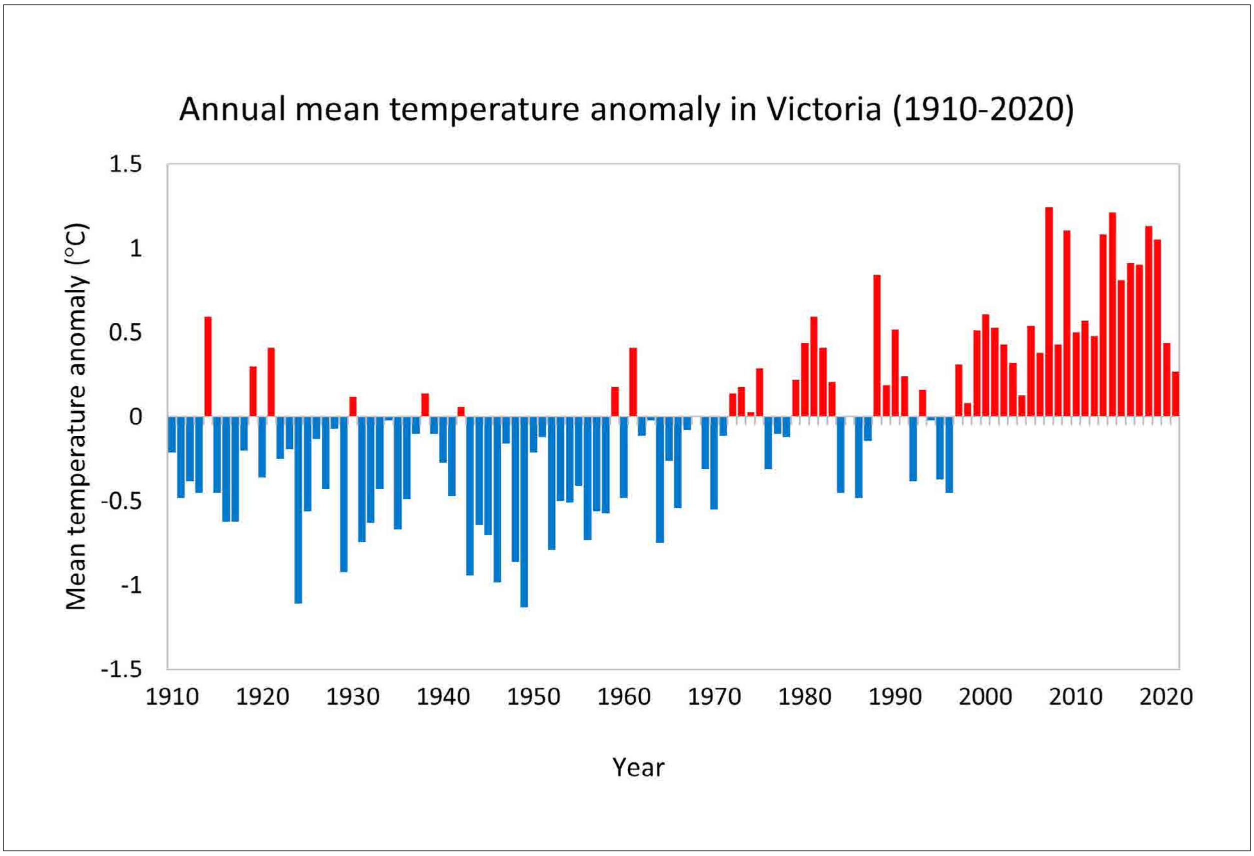


Figure Fo19: Mean temperature anomaly (1961-1990) in Victoria between 1910 and 2021.[1372]

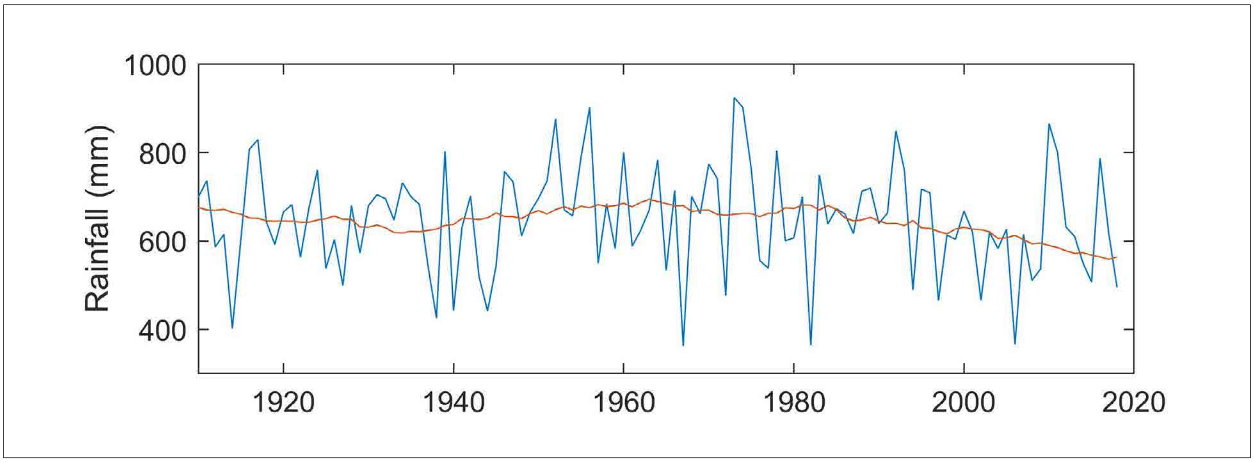


Figure Fo20: Annual rainfall in Victoria between 1920 and 2020.[1373] Blue line denotes the annual rainfall values and the red line is the 11-year running average.

1372. Bureau of Meteorology (BOM) 2023, 'Climate change - trends and extremes', http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=timeseries&tQ=graph%3Dtmean%26area%3Dvic%26season%3D0112%26ave_yr%3D0 Accessed 4 May 2023.

1373. Ibid.

Forests

CSIRO and BOM's leading scientists indicated that climate change has driven a significant increase in Australia's forest fire activity over the last three decades.[1374] They found that out of eight drivers of fire-activity that played varying roles in influencing forest fires, climate was the overwhelming factor driving fire activity. The increase in forest area burnt is consistent with the increasing in more dangerous fire weather conditions. This, coupled with the association of pyro-convection which includes fire-generated thunderstorms and increased ignitions from dry lightning, will generate more risk to Victorian community and environment. South-eastern Australia has a shortened frequency of forest megafires, resulting in some areas with fire intervals shorter than 20 years. This will cause a significant impact on some types of vegetation as they will not reach maturity, which could put ecosystems at risk. These findings were also supported by another academic research project whose results also point to climatic conditions and fire weather as being highly influential factors in an increase in the size and severity of wildfires.[1375]

Forests could be vulnerable to climate change impacts. Modelling shows that blue gum plantation estates could be adversely impacted by climate change, with heightened uncertainty in long term outcomes.[1376] Some regions may experience an increase of mortality rate with increased risk in pests and diseases.

Considering an increase of average temperatures across Victoria, as well as an increase in the number and duration of extreme hot weather events, large cities also can experience higher than average temperatures — a phenomenon referred to as the heat island effect — which could impact on metropolitan Victorians. This is typically caused by man-made infrastructure and buildings, but climate change is expected to worsen this phenomenon. About half of metropolitan Melbourne was 5°C above the city's estimated non-urban baseline temperature.[1377] Urban trees and forests, however, could be an effective mitigation measure by creating shading systems that can reduce surface temperatures in urban areas during daytime, resulting in human thermal comfort as well as benefiting biodiversity.[1378] Based on the canopy cover in Melbourne, which could be an important measure of understanding the current status of metropolitan Melbourne's urban forest, the eastern (25%) and inner south-east regions (22%) had the highest canopy cover in 2019 while the western region (4%) had the lowest cover.[1379]

1374. Canadell JG, Meyer, C.P, Cook GD, Dowdy A, Briggs PR, Knauer J, Pepler A, Haverd V 2021, 'Multi-decadal increase of forest burned area in Australia is linked to climate change'. *Nature Communication* 12, pp. 6921, https://doi.org/10.1038/s41467-021-27225-4 Accessed 20 April 2023.
1375. Collins L, Clarke H, Clarke MF, McColl Gausden SC, Nolan RH, Penman T, Bradstock R 2022, 'Warmer and drier conditions have increased the potential for large and severe fire seasons across south-eastern Australia', *Global Ecology and Biogeography*, 31, pp. 1933–1948, https://doi.org/10.1111/geb.13514 Accessed 20 April 2023.
1376. Battaglia M, Bruce J 2017, 'Direct climate change impacts on growth and drought risk in blue gum (*Eucalyptus globulus*) plantations in Australia', *Australian Forestry*. 80, pp. 216-227, https://doi.org/10.1080/00049158.2017.136540 Accessed 20 April 2023.
1377. Hartigan M, Fitzsimons J, Grenfell M, Kent T 2021, 'Developing a Metropolitan-wide urban forest strategy for a large, expanding and densifying capital city: lessons from Melbourne, Australia', *Land*, 10(8), pp. 809, https://doi.org/10.3390/land10080809 Accessed 20 April 2023.
1378. Sankar Cheela VR, John M, Biswas W, Sarker P 2021 'Combating urban heat island effect - a review of reflective pavements and tree shading strategies', *Buildings*, 11, pp. 93, https://doi.org/10.3390/buildings11030093 Accessed 24 May 2023.
1379. Ibid.

Forests

Indicator Fo:09A Area and type of human-induced disturbance - planned burns

Fo:09A Area and type of human-induced disturbance – planned burns

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	↙	🟢	🟡	?	🟢

Data source(s):	DELWP
Measure(s):	Annual area of planned burns on public land, by fire management zone Annual planned burn area

Why this indicator?

Disturbance from human land-use and management activities may result in different biotic responses and disrupt ecological relationships.

Why this assessment in 2023?

The Victorian Government has changed bushfire management activities from a hectare-based approach to a risk-based approach. Using the results of fire modelling, this new approach focuses on areas estimated to have the greatest level of fire impact. Victoria's bushfire risk has been maintained below 70% of its maximum bushfire risk since the introduction of the risk target for the fuel management program. On average, planned burning accounted for more than two-thirds (70%) of the total risk reduction, compared to one-third (30%) for bushfires. A rapidly changing climate has likely worsened the forest fire danger index (FFDI) over the past 40 years. This means it is even more important to mitigate more frequent, severe or higher FFDI through planned burning.

Despite fluctuations in the area receiving planned burns, DEECA has been meeting a statewide residual risk target. The window for planned burning is narrowing, likely as a result of climate change, where the number of days for conducting burns during suitable weather and with appropriate fuel conditions has decreased relative to historical records. This suggests that the trend could continue to deteriorate.

Summary of State of the Environment 2018 Report assessment

- Following the final report by the 2009 Victorian Bushfires Royal Commission, the Victorian Government committed to expanding its planned-burning approach by aiming to reduce fuel hazards and protect human life.
- Based on recommendations by the Inspector-General for Emergency Management and the Commissioner for Environmental Sustainability, the government began to shift from a hectare-based approach to a risk-based approach to bushfire management in 2016. This risk-based approach uses fire-modelling results to identify and target areas where the likelihood of a bushfire starting, spreading and impacting on people, property and the environment is greatest.
- The government is developing a system of bushfire management strategies to reduce risk, with an expected delivery of 2020. A strategic change in planned-burning targets prevents trend analysis.

Critical data used for the 2023 assessment

- Annual area of planned burns on public land, by fire management zone (2003-04 to 2020-21)
- Area of fuel reduction burns (2003-04 to 2020-21)

2023 assessment

Fuel management is an effective way to manage bushfire risk within large areas of public land. Fuel management reduces the amount of fuel available to a bushfire, which can reduce its intensity and rate of spread, thereby increasing opportunities for firefighters to suppress it. Victoria primarily manages fuel by planned burns, but mechanical treatment is also used. Prescribed burning is an important element in managing risks in our economy, society and environment in the future, and will be essential to managing fire in forests and other vegetation at the landscape scale. Victoria has four fire management zones for fuel management purposes (description of each zone can be found in the SoE 2018 Report).

Forests

DEECA conducts planned burns to meet the objectives of the relevant fire management zone and other site-specific objectives. Based on the Inspector-General for Emergency Management's recommendation in 2016, the Victorian Government has now changed bushfire management activities from a hectare-based approach to a risk-based approach. This approach uses fire modelling results to focus on areas estimated to have the greatest fire impact.

The 2019-20 Fuel Management program was heavily impacted by the 2019-20 bushfires, which reduced the proposed area to treat through planned burning from 230,000 hectares to 100,000 hectares. As a result, most of the planned burning was delivered in mid-March through to June. The area receiving planned burning was also affected by the 2019-20 bushfires, along with other more recent factors like COVID-19 and La Nina, which together resulted in annual variability in the area of planned burning (Figure Fo21). Figure Fo22 presents the area receiving planned burning by management objective and shows that the largest areas of planned burning for fuel reduction purposes occurred in 2012-13.

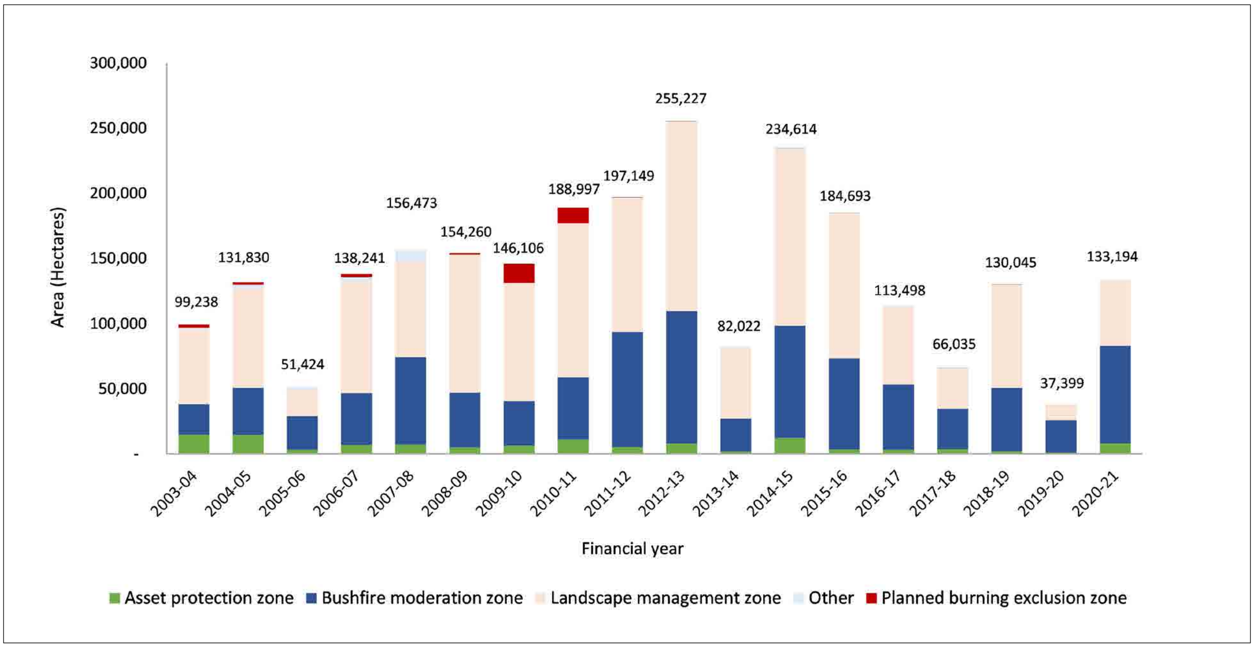


Figure Fo21: Annual area of planned burns on public land in Victoria by fire management zone between 2003–04 and 2020–21.[1380, 1381, 1382, 1383, 1384]

Under the risk-based approach, DELWP currently established residual bushfire risk targets for across the state, as well as regions with long-term targets, to evaluate the efficacy of planned burns on public land. DELWP released new analyses that show the relative contributions of planned burning and bushfires to risk reduction.[1385]

Between 2009 and 2021, planned burning accounted for around two-thirds (70%) of the total risk reduction, compared to one-third (30%) for bushfires. This was achieved while bushfires burned 747,000 hectares more than planned burning. DELWP claims that planned burning has been effectively working to reduce bushfire risks to human life, environment, infrastructure and economy.

[1380] Commissioner for Environmental Sustainability (CES) 2018, 'State of the environment 2018 report', Melbourne, Victoria.

[1381] Department of Environment, Land, Water and Planning (DELWP) 2018, 'Managing Victoria's bushfire risk: Fuel management report 2017-18', Melbourne, Victoria.

[1382] State Government of Victoria, 'Fuel management report 2018-19: fuel management activities', Melbourne, Victoria, https://www.ffm.vic.gov.au/fuel-management-report-2018-19/statewide-achievements/fuel-management-activities Accessed 2 May 2023.

[1383] Forest Fire Management Victoria, 'Fuel management report 2019-20: fuel management delivery', Melbourne, Victoria https://www.ffm.vic.gov.au/fuel-management-report-2019-20/statewide-achievements/fuel-management-activities Accessed 2 May 2023.

[1384] Ibid.

[1385] Forest Fire Management Victoria, 'Fuel management report 2020-21: bushfire risk to life and property and ecological values', Melbourne, Victoria, https://www.ffm.vic.gov.au/fuel-management-report-2020-21/statewide-achievements/bushfire-risk Accessed 5 May 2023.

To better understand this, the Commissioner for Environmental Sustainability further requested an alternative reporting approach which includes an analysis of absolute risk reduction effect over a period and the delineation of the contribution of fuel management and bushfire. DELWP advised that the additional analyses would require a comparison between multiple scenarios (a landscape with no fire history and landscapes with either a history of bushfire or planned burning) that is then validated by research experts, however, this work could not be delivered with the available resources and within the timeframe needed for it to be included in this SoE 2023 Report.[1386]

CSIRO found that there is a clear link between the number of very high or severe fire danger days with areas subsequently burnt by fire, based on 32 years of fire index data across Australia's forest zones. The link specifies that, with a 300% to 500% increase in burnt area for every extra day of severe fire danger, there is a 21% increase in burnt area for every extra day of very high fire danger.[1387] This increase in burnt area is related to a critical change in what factor drives fire spread above the severe forest fire danger index (FFDI). Research on the effect of prescribed burning on wildfire severity from the 2003 fires in Victoria found that landscape-scale fires became 'weather-dominant' at FFDI 50 (severe), and fuel and topography became less important to the continued fire spread.[1388] FFDI has been steadily worsening over the past 40 years.[1389] This provides critical implications for planned burning, as a greater use of prescribed burning to reduce wildfire risks and impacts would be required to mitigate more frequent severe or higher FFDI. This should not be achieved by simply committing to an increase in resources for wildfire suppression.[1390]

Morgan et al (2020) argue that:

> There is compelling evidence for the greater use of prescribed burning to reduce wildfire risks and impacts, rather than committing increasing resources to wildfire suppression. The potential negative impacts of prescribed burning can be managed effectively using existing knowledge and tools. Clear communication of the benefits of prescribed burning can influence political and public opinion in its favour. More investment in training, human capacity and supporting resources is required to safely and effectively deploy prescribed burning more widely to reduce future wildfire risks.' [1391]

However, other scientists have reported that the reduction of fuel loads did little to stop fires ignited in extreme weather and during drought.[1392]

In an analysis of planned burning in 30 regions in south-eastern Australia from 1975 to 2009, Price et al (2015) found that leverage (the reduction in bushfire area burnt resulting from previous planned burning) occurred in only four bioregions in the forested mountains of the Great Dividing Range along the east coast, including the New England Tableland, New South Wales North Coast, Sydney Basin and Australian Alps/South Eastern Highlands bioregions.[1393] The scientists concluded that 'in most Bioregions prescribed burning is likely to have very little effect on subsequent extent of unplanned fire, and even in regions where leverage occurs, large areas of treatment are required to substantially reduce the area burned by unplanned fire.' [1394]

1386. Department of Energy, Environment, and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.
1387. Cook G, Dowdy A, Knauer J, Meyer M, Canadell P, Briggs P 2021, 'Australia's Black Summer of fire was not normal - and we can prove it', *The Conversation*, https://theconversation.com/australias-black-summer-of-fire-was-not-normal-and-we-can-prove-it-172506 Accessed 27 October 2022.
1388. Tolhurst K, McCarthy G 2016, 'Effect of prescribed burning on wildfire severity: a landscape-scale case study from the 2003 fires in Victoria', *Australian Forestry*, 79:1, 1-14, DOI: 10.1080/00049158.2015.1127197. Accessed 20 April 2023.
1389. Cook G, Dowdy A, Knauer J, Meyer M, Canadell P, Briggs P 2021, 'Australia's Black Summer of fire was not normal - and we can prove it', *The Conversation* https://theconversation.com/australias-black-summer-of-fire-was-not-normal-and-we-can-prove-it-172506 Accessed 27 October 2022.
1390. Morgan G, Tolhurst K, Poynter M, Cooper N, McGuffog T, Ryan R, Wouters M, Stephens N, Sheehan B, Leeson P, Whight S, Davey S 2020, 'Prescribed burning in south-eastern Australia: history and future directions', *Australian Forestry*, 83(1), pp. 4-28, DOI: 10.1080/00049158.2020.1739883 Accessed 20 April 2023.
1391. Ibid.
1392. Penman T, Parkins K, McColl-Gausden S 2019, 'A surprising answer to a hot question: Controlled burns often fail to slow a bushfire', The Conversation 15 November 2019, https://theconversation.com/a-surprising-answer-to-a-hot-question-controlled-burns-often-fail-to-slow-a-bushfire-127022 Accessed 20 April 2023
1393. Price O, Penman T, Bradstock R, Boer M, Clarke H 2015, 'Biogeographical variation in the potential effectiveness of prescribed fire in south-eastern Australia', *Journal of Biogeography*, 42(11), pp. 2234–2245.
1394. Ibid

Forests

Florec et al (2020) evaluated the long-term costs and benefits of planned burns at the wildland-urban interface and in rural landscapes.[1395] This work showed that there was a greater reduction in damages at the interface, although it was also more expensive and less economically efficient. A broad review of planned burning research by the Bushfire Recovery Project also found planned burning to be most effective (although more expensive) when performed in proximity to the assets as reduced fuel loads in 'close to houses also creates a defensible space in which fire suppression has a better chance of being successful, except in extreme fire weather conditions.'[1396] The distance between planned burns and assets would vary depending on house ignitability, housing density and surrounding vegetation type.

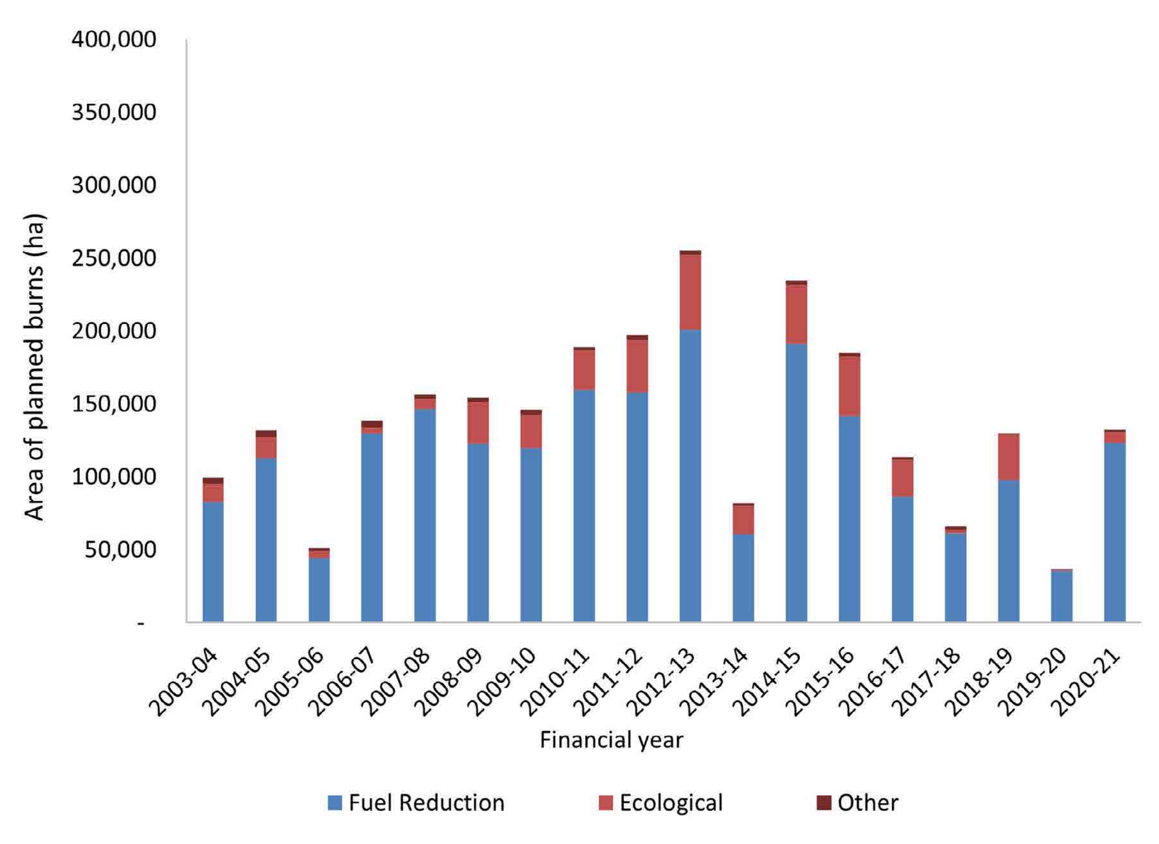


Figure Fo22: Area of planned burns in Victoria from 2003-04 to 2020-21.[1397, 1398, 1399, 1400, 1401] Planned burns aimed at reducing fuel levels are shown in blue. Planned burns aimed at achieving ecological objectives are shown in light red. Planned burns denoted as 'other' include regeneration and catchment protection burns and are shown in dark red.

[1395] Florec V, Burton M, Pannell D, Kelso J, Milne G 2020, 'Where to prescribe burn: The costs and benefits of prescribed burning close to houses', *International Journal of Wildland Fire*, 29, pp. 440–458.

[1396] Ibid.

[1397] Commissioner for Environmental Sustainability (CES) 2018, 'State of the environment 2018 report', Melbourne, Victoria.

[1398] Department of Environment, Land, Water and Planning (DELWP) 2018, 'Managing Victoria's bushfire risk: fuel management report 2017-18', Melbourne, Victoria.

[1399] Forest Fire Management Victoria, 'Fuel management report 2018-19: fuel management activities', Melbourne, Victoria, https://www.ffm.vic.gov.au/fuel-management-report-2018-19/statewide-achievements/fuel-management-activities Accessed 2 May 2023.

[1400] Forest Fire Management Victoria, 'Fuel management report 2019-20: fuel management delivery', Melbourne, Victoria, https://www.ffm.vic.gov.au/fuel-management-report-2019-20/statewide-achievements/fuel-management-activities Accessed 2 May 2023.

[1401] Ibid.

Indicator Fo:09B Area and type of human-induced disturbance - grazing

Fo:09B Area and type of human-induced disturbance – grazing

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	↗	🔴	●	→	🔴
Data source(s):	ABS					
Measure(s):	Information on grazing licences, location and intensity, including its potential impact on forest-dwelling flora					

Why this indicator?

About two-thirds of Australia's land has been modified for human use, primarily for grazing on natural vegetation. Pastoral farming is a major contributor to Australia's economy. However, grazing affects the conservation of ecosystems like grasslands. Studies indicate that grazing by non-native animals, such as cattle and sheep, negatively impacts native plant biodiversity and water yield. To balance land used for nature conservation and agriculture, the Victorian Government has been regulating grazing by issuing licences and permits on public lands.

Why this assessment in 2023?

Data limitations have prevented a status assessment. Currently, there iare no data available on the impacts (negative or positive) of grazing in Victoria, and monitoring of grazing licences is also lacking. Thus, there is an urgent need for an evidence-based approach to determine the sustainable level of grazing activity in Victoria.

Summary of State of the Environment 2018 Report assessment

- The number of grazing licences and payments for rent or other activities on Crown land were stable in the reporting period. However, it was difficult to assess status, as the relationship between licence numbers and environmental impact is unknown.
- No information on the size of grazing area has been identified.

Critical data used for the 2023 assessment

- Physical change (ha) for land cover (2010-11 to 2015-16)

2023 assessment

Grazing activity is an important topic for in the context of conservation of native plant biodiversity, water yield and agricultural practices. Pastoral farming is a major contributor to Australia's economy. About two-thirds of Australia's land has been modified for human use, primarily for grazing on natural vegetation.[1402] Studies indicate that grazing by non-native animals, such as cattle and sheep, could negatively impact native plant biodiversity and water yield.[1403, 1404] To balance between the combined use of land for nature conservation and agricultural use, the Victorian Government has been regulating grazing by issuing licences and permits.

As indicated in the SoE 2018 Report, there has not been any relevant information to assess this indicator. DEECA advised that the Vicmap Crown Land Tenure dataset contains spatial data regarding issued grazing licenses. In this layer, all the agricultural licenses are recorded as polygons along with other licenses, meaning that it was difficult to differentiate grazing licenses among the other licenses.

1402. Australian Bureau of Statistics (ABS) 2010, '4613.0-Australia's environment: issues and trends, Jan 2010', Belconnen, Australia http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4613.0Chapter95Jan+2010 Accessed 4 December 2018.
1403. Bromham L, Cardillo M, Bennett AF, Elgar MA 2009, 'Effects of stock grazing on the ground invertebrate fauna of woodland remnants', *Austral Ecology*, 24(3), pp. 199-207.
1404. Lunt ID 2005, 'Effects of stock grazing on biodiversity value in temperate native grasslands and grassy woodlands in SE Australia: a literature review'. Technical Report 18, Wildlife Research and Monitoring, Lyneham, Australian Capital Territory.

In addition, this spatial information does not contain the area of active grazing and the exact date of issue for those grazing licenses, making it difficult to determine whether the current number of grazing licenses is at a sustainable level. There is an urgent need for an evidence-based approach to determine the sustainable level of grazing, therefore, the status for this indicator is assessed as unclear.

About 45% of Australia's soil is used for agricultural production, with 84% of this being used for grazing.[1405] In Victoria, area used for grazing decreased by around 717,000 hectares between 2010-11 and 2015-16 (Figure Fo23), which is around a 11% reduction of area that were used for grazing. Therefore, the trend for this indicator is assessed as improving.[1406]

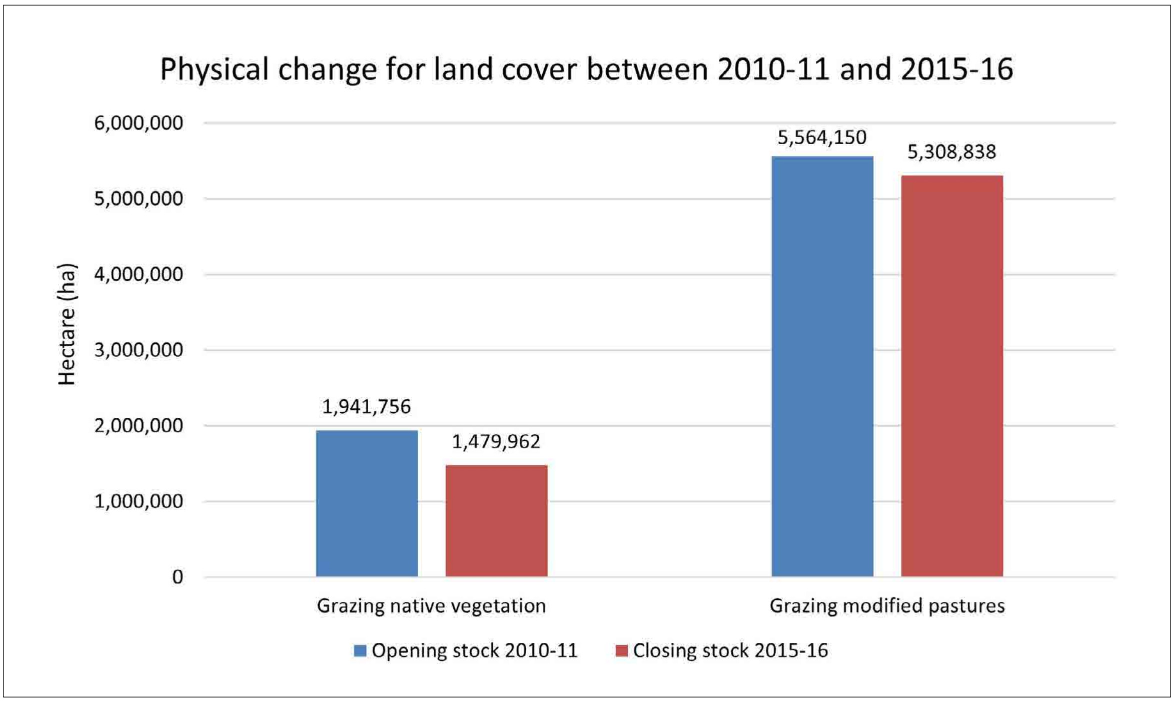


Figure Fo23: Amount (ha) of physical change for land cover in Victoria between 2010-11 and 2015-16.[1407]

Note: two categories (grazing native vegetation and grazing modified pastures) were selected to be related to grazing among other land-use activities, including dryland cropping, irrigated pastures and intensive horticulture and animal production.

Carbon cycles

Carbon cycle is an increasingly important issue for tackling global climate change. Understanding how forest ecosystems are contributing to the state's progress in reducing carbon emission, as well as the impact of forest disturbances on forest carbon stock, together provides key insights into emission reductions. This theme looks into the current status of carbon stocks in forest ecosystem and their net contribution to overall GHG balance in Victoria.

[1405] Commonwealth of Australia 2021, 'Australian state of the environment', https://soe.dcceew.gov.au/ Accessed 22 August 2022.

[1406] Australian Bureau of Statistics (ABS) 2022, 'National land account, experimental estimates: The national land account provides statistics to measure changes in land attributes over time, both from an economic and an environmental perspective', Canberra, Australian Capital Territory, https://www.abs.gov.au/statistics/environment/environmental-management/national-land-account-experimental-estimates/latest-release#methodology Accessed 22 August 2022.

[1407] Ibid.

Forests

Indicator Fo:10 Total forest ecosystem biomass and carbon pool by forest type, age class and successional stages

Fo:10 Total forest ecosystem biomass and carbon pool by forest type, age class and successional stages						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	●	?	🔴	🟡	?	🟡
Data source(s):	DELWP					
Measure(s):	Change of total carbon stock by forest type, age class and successional stages					

Why this indicator?

This indicator estimates total forest biomass and the total carbon pool within Victorian forests by forest type and age class. These indices can provide the rate of change of the total forest ecosystem carbon pool over time to increase understanding of how different forest types and age classes have been contributing to carbon sinks.

Why this assessment in 2023?

Forest carbon stock fluctuates depending on the degree and intensity of disturbances. One major factor for the fluctuation of carbon pool in forest ecosystems in Victoria is bushfire, as it burns biomass and releases carbon into the atmosphere on a landscape scale. Released carbon will be sequestrated gradually over time due to post-fire regrowth. This pattern is captured in the Australian Government's FullCAM modelling program. There were approximately 1.1 billion tonnes of carbon in Victoria's forests within RFA regions during 2017, and a net loss of about 55-million tonnes as a result of the 2019–20 bushfires.

The FullCam modelling assumes, under the forest neutrality assumption, that the net loss will be returned gradually due to forest regrowth after the fires. However, this assumption has been challenged, highlighting the need for more research on the impact of more frequent and severe fires on fire-tolerant forests.

There is no information on carbon pool by forest type, age class and successional stage; only data on carbon stock by tenure were available for this assessment. Therefore, the status and trend could not be determined.

Summary of State of the Environment 2018 Report assessment

- Data from the VFMP shows that across all Victorian public forests, the average carbon and biomass per hectare is 166.2 tonnes and 332.3 tonnes, respectively.
- The Murray–Darling Depression has the lowest average carbon and biomass per hectare, with 39.9 and 79.9 tonnes per hectare, respectively.
- Across all bioregions, total carbon per hectare is, on average, 40% higher in state forests than in parks and reserves, except for the Flinders bioregion.
- Although parks and reserves are known to occupy a higher proportion of total Crown Land, state forests support greater sink capacity through total plant biomass. The higher prevalence of old-growth trees restricted for timber harvest in state forests, relative to younger stands, may contribute to greater carbon storage.
- Trend analysis will be possible from 2020, once the 5-year panel system is fully implemented.

Critical data used for the 2023 assessment

- Ecosystem Services from Forests in Victoria - Assessment of RFA Regions
- Ecosystem Services from Forests in Victoria - Impact of the 2019-20 Bushfires
- Major Event Review of the 2019-20 Bushfires

2023 assessment

Carbon is a fundamental component of terrestrial forest ecosystems, including above- and below-ground biomass, organic soil matter, woody debris and litter. The natural process of photosynthesis by plants enhances terrestrial uptake of atmospheric carbon, making forests ideal for reducing the net carbon emissions from anthropogenic activities.[1408] Strategies to increase forest-stored carbon would thus assist in meeting state and national carbon emissions commitments. This indicator provides information on the contribution of Victorian forests to the carbon cycle. Estimates of total forest biomass overtime are vital to monitor the changes in regional and localised carbon pool distribution, particularly as carbon stocks are contingent on environmental and land-use conditions.[1409]

DELWP previously provided detailed information on carbon stocks per bioregion for parks and reserves and state forests derived from a combination of satellite information and field data. DELWP's analysis, conducted in 2017 using biomass data from the VFMP with integrated timeseries Landsat satellite images, enabled the calculation of above-ground carbon stocks across RFA regions to be performed. This work found that around 1.1 billion tonnes of carbon were stored, with stocks fluctuating due to a range of factors, including bushfires. The effects of bushfire on carbon stock were demonstrated in the Gippsland and North East RFA regions where the 2006-07 bushfires caused the stock to drop to around 0.895 billion tonnes during that year.

Although the detailed information on carbon stocks in Victoria was not able to be updated in this report, it will be included in the SoF 2023 Report and enable status and trend analyses to be conducted. Due to this absence of current data on carbon stocks, DELWP's report on the ecosystem services from RFA regions was instead used for this indicator. [1410, 1411] This means that this report cannot provide information on the carbon pool by forest type, age class and successional stages.

One major event that might have impacted on carbon sequestration in Victoria was the 2019-20 bushfire event. The Victorian Government's report on the impact of the 2019-20 bushfires shows that there would be an expected net reduction of 55 million tonnes in forest carbon stock within RFA regions due to the 2019-20 bushfires.[1412] The net reduction was calculated as a loss of 57 million tonnes due to fire, and sequestration of two million tonnes because of regrowth after fire. Of the fire-affected RFA regions, East Gippsland had the greatest loss of carbon stocks (36 million tonnes) followed by North East (10 million tonnes) and Gippsland (9 million tonnes).[1413] The net loss of 55 million tonnes of carbon stock is around a 3% decrease in carbon retention across the whole of the state.[1414]

However, one issue identified by the Major Event Review report is that this estimation assumes that the net loss would be returned under the forest neutrality assumption in forest regrowth after the fires.[1415, 1416] The carbon neutrality assumption about burnt forests is based on the view that fire-adapted forests, such as eucalypts, rapidly recover resulting in only a negligible effect on their carbon stocks. Recently this assumption has been tested by several researchers. Bowman et al. (2020), for example, have challenged the assumption after reviewing the impacts of the 2019–20 bushfires and argued that the 'combination of drought and frequent fires is likely reducing the capacity to recover from the fire so future Australian forests may store less carbon', preventing forests from replacing all of the carbon lost to the atmosphere.[1417]

[1408] Zhu K, Zhang J, Niu S, Chu C, Luo Y 2018, 'Limits to growth of forest biomass carbon sink under climate change'. *Nature Communications*, 9(1), pp. 2709.

[1409] Keith H, Mackey B, Lindenmayer D, Likens G 2009, 'Re-evaluation of forest biomass carbon stocks and lessons from the world's most carbon-dense forests' Proceedings of the National Academy of Sciences of the United States of America, 106(28), pp. 11635-11640.

[1410] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Ecosystem services from forests in Victoria - Assessment of Regional Forest Agreement regions', Melbourne, Victoria.

[1411] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Ecosystem services from forests in Victoria: impact of the 2019–20 bushfires', https://www.environment.vic.gov.au/__data/assets/pdf_file/0023/555116/Ecosystem-services-from-forests-in-Victoria-Impact-of-the-2019-20-bushfires.pdf Accessed 2 February 2022.

[1412] Ibid.

[1413] Ibid.

[1414] Ibid.

[1415] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

[1416] Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian Regional Forest Agreement Major Event Review of the 2019–20 bushfires: Summary report: information and data to inform public consultation', https://www.delwp.vic.gov.au/__data/assets/pdf_file/0023/542156/Summary_Report_May_2021_-_Accessible_Version_002.pdf Accessed 1 March 2022.

[1417] Ibid.

Similarly, research conducted by the University of Melbourne indicates potential decreases in carbon stability of fire-tolerant forests under future predictions of more frequent, extensive and severe bushfires.[1418, 1419] One such study found that high-severity bushfires in 2009 decreased the carbon stability of a fire-tolerant forest by significantly decreasing absolute and proportional carbon stores in live trees, which would likely influence storage recovery rates.[1420]

It is not clear if and how the FullCAM model that is embedded in the Australian National Greenhouse Accounts can, or will, accommodate tree mortality and/or changed productivity due to severe fire, short-interval wildfires, and interactions with climatic factors, including drought and heat. Therefore, the Independent Panel of the Major Event Review report recommended reporting on the potential impact on post-fire productivity that is currently assumed to recover the amount that was lost from bushfires.

Tree sap.
© Parks Victoria.

[1418] Clarke HG, Smith PL, Pitman AJ 2011, 'Regional signatures of future fire weather over eastern Australia from global climate models', *International Journal of Wildland Fire*, 20, pp. 550-562.

[1419] King KJ, Cary GJ, Bradstock RA, Marsden-Smedley JB 2013, 'Contrasting fire responses to climate and management: insights from two Australian ecosystems', *Global Change Biology, 19, pp. 1223-1235.*

[1420] Bennett LT, Bruce MJ, MacHunter J, Kohout M, Krishnaraj SJ, Aponte C 2017, 'Assessing fire impacts on the carbon stability of fire-tolerant forests', *Ecological Applications*, 27, pp. 2497-2513.

Forests

Indicator Fo:11 Contribution of forest ecosystems to the global greenhouse gas balance

Fo:11 Contribution of forest ecosystems to the global greenhouse gas balance						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🟢	↗	🟢	🔴	↗	🟢
Data source(s):	DCCEEW, DELWP					
Measure(s):	CO_2 emissions by sector Amount of net carbon sink under Victoria's LULUCF and significance of the carbon sink amount to mitigate GHG emissions in Victoria					

Why this indicator?

Increasing the concentration of GHGs causes an intensification of climate change. Monitoring the contribution of Victorian forest ecosystems to the global GHG balance is an important management strategy, as forest management can have a positive, or negative, impact on the balance.

Why this assessment in 2023?

In 2020, Victoria's land use, land use change and forestry (LULUCF) sector has been a net sink for GHGs. The 21,054 CO2-e was equivalent to about a quarter of Victoria's total emissions in that year. This is a significantly higher proportion than national figures for the LULUCF sector (7.8%). However, Victoria's GHG abatement activities through the Australian Government's Emissions Reduction Fund were mainly achieved by non-forestry sectors, while the forest-related activity under the fund contributed less than 5% in 2020.

There has been a gradual decrease of overall GHG emissions in Victoria, and the LULUCF sector has been increasing net sink contributions over the past 10 years.

Summary of State of the Environment 2018 Report assessment

- From 1990 to around 2010, Victoria's net GHG emissions gradually increased by 35% to 110,469 gigagrams CO2-e. In 2016, net GHG emissions in Victoria were 91,459 gigagrams CO2-e — about a 12% increase from 1990 emissions.
- The 20-year increase was due primarily to emissions from the energy sector, the greatest contributor to net emission outflow. The sector includes production of electricity and direct combustion of fossil fuels in other industries, such as manufacturing. However, the energy sector's contribution has stabilised since 2004, and the LULUCF sector has become a net sink of carbon emissions, except for the years when major bushfires occurred (2003, 2007 and 2009).
- The primary driver of forest-related carbon sequestration (removal) is afforestation/ reforestation activities; however, these figures peaked in 2012 and decreased gradually until 2016.

Critical data used for the 2023 assessment

- GHG inventory (carbon dioxide) trend by sector in Victoria (1990 and 2020)
- LULUCF sector emissions (1990-2020)
- Contribution of LULUCF sector to overall GHG emission in Victoria and Australia
- Emissions Reduction Fund register in Victoria (2013-14 to 2021-22)
- The forest neutrality assumption in forest regrowth after the multiple high severity fires

2023 assessment

In 2020, net GHG emissions in Victoria were 83,274 gigagrams CO2-e, which is about a 33% decrease from 1990 (Figure Fo24). For about 20 years from 1990, Victoria's net GHG emissions gradually increased by 20% to reach 139,783 gigagrams CO2-e. This increase is primarily due to emissions from the energy sector, which is the greatest contributor to net emission outflow.

The sector includes production of electricity and direct combustion of fossil fuels in other industries, such as manufacturing. Since 2010, GHG emission in the energy sector started to decrease until 2020, resulting in a 30% reduction of emissions. The LULUCF sector was a net sink of carbon emissions since 2013. For some years, the LULUCF sector had net carbon sources except for the years when major bushfires occurred, including 2009.[1421]

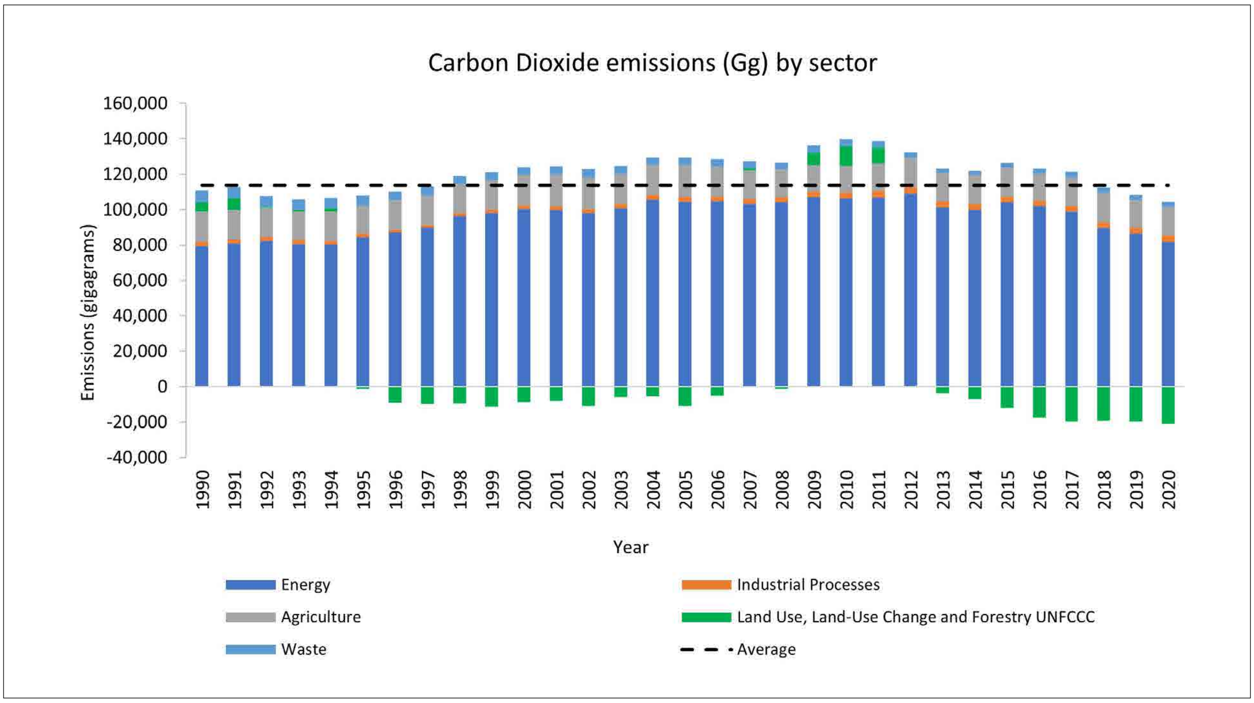


Figure Fo24: Trend in greenhouse gas inventory (carbon dioxide) by sector in Victoria between 1990 and 2020.[1422]

LULUCF sector covers emissions resulting from activities affecting land use and vegetation cover, including land clearing and regeneration, forest management and plantations on public and private land. Since 2014, the sector has been increasing its contribution as a net carbon sink. In 2020, the sector emitted around 1,900 CO2-e but sequestrated around 23,000 CO2-e (Figure Fo25), which is equivalent to around 27% of Victoria's total emissions in that year. The largest contribution of carbon sequestration occurred in 2020 from forested land at 89% (18,810 CO2-e). Nationally, the LULUCF sector has been a net carbon sink since 2016, with approximately 5.4% of overall carbon emission from all sectors in 2016 and 7.8% in 2020 (Figure Fo26). Importantly, over that period, Victoria's LULUCF sector had the greatest contribution towards the sequestration of Victoria's carbon emissions from all sectors, and this trend has been intensifying from 17% in 2016 to 25% in 2020 (Figure Fo26). Therefore, the status of this indicator is assessed as good.

1421. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian greenhouse gas emissions report', Melbourne, Victoria, https://www.parliament.vic.gov.au/file_uploads/Victorian_Greenhouse_Gas_Emissions_Report_2020_tH8912bV.pdf Accessed 6 January 2023.
1422. Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Emissions by state and territory', https://www.greenhouseaccounts.climatechange.gov.au/ Accessed 4 May 2023.

Forests

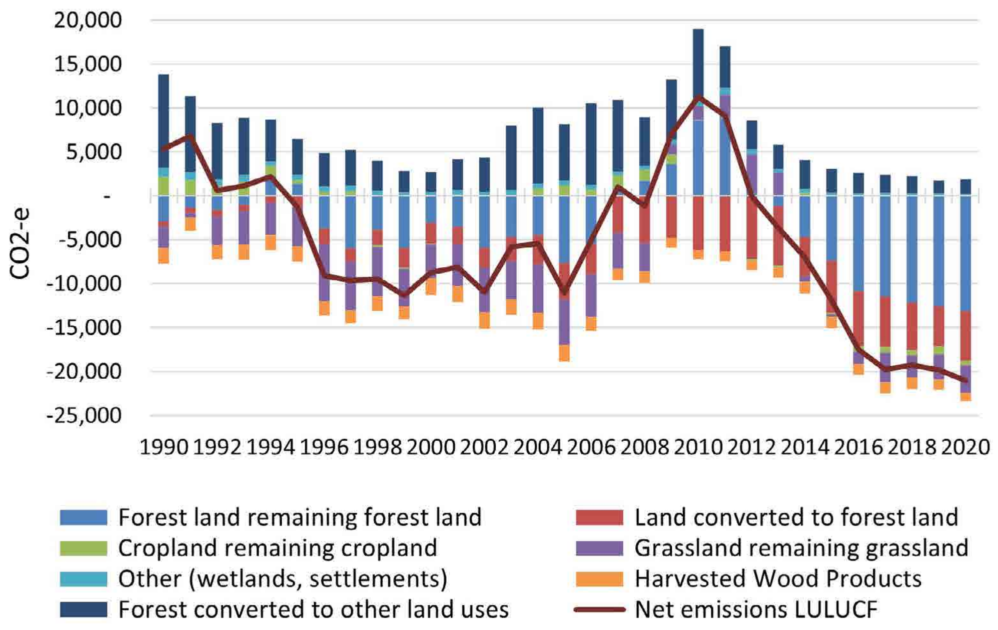


Figure Fo25: Greenhouse gas emissions (carbon dioxide) by the LULUCF sector in Victoria between 1990 and 2020.[1423]

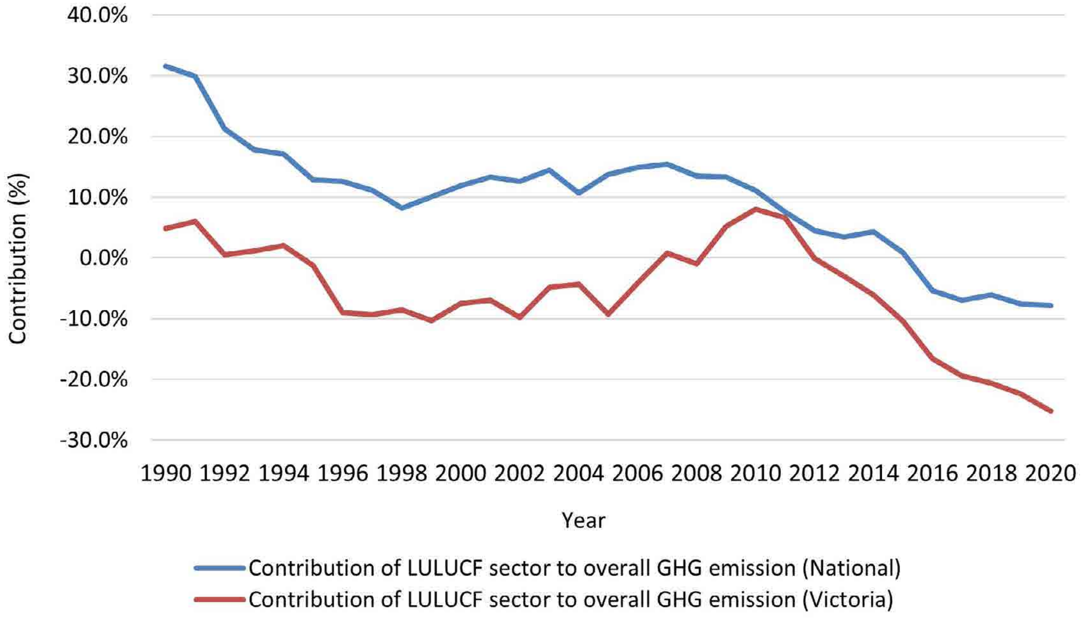


Figure Fo26: Contribution to the overall greenhouse gas emissions by the LULUCF sector in Victoria and Australia between 1990 and 2020.[1424, 1425]

[1423] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'National greenhouse accounts 2020', https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020 Accessed 20 April 2023.

[1424] Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Emissions by state and territory', https://www.greenhouseaccounts.climatechange.gov.au/ Accessed 4 May 2023.

[1425] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'National greenhouse accounts 2020', https://www.dcceew.gov.au/climate-change/publications/national-greenhouse-accounts-2020 Accessed 20 April 2023.

Forests

The Emissions Reduction Fund program provides the opportunity to landholders, communities and businesses to run projects in Australia that avoid the release of GHG emissions or remove and sequester carbon from the atmosphere.[1426] Projects can earn carbon credit units called Australian carbon credit units (ACCUs). Each unit represents one tonne of carbon dioxide equivalent (CO2-e) emissions stored or avoided by a project. Among all ACCUs, Kyoto ACCUs are issued 'if the relevant offsets project is an eligible Kyoto project and the reporting period ends on, or before, the Kyoto abatement deadline'.[1427] Among the methods to claim Kyoto ACCUs, the vegetation method is one option that is related to the LULUCF sector. This method includes projects that generate abatement by removing carbon dioxide from the atmosphere and storing it as carbon in plants as they grow. This includes reforestation, revegetation or protecting native forest or vegetation that is in imminent risk of clearing.[1428]

The estimated net contribution of the Emissions Reduction Fund program to the sequestration by the LULUCF is still low, as only just above 4% of the units issued in Victoria are related to the vegetation method (Figure Fo27). Although the proportional contribution of the vegetation method is increasing, its contribution is still minimal compared to other methods, including waste and agriculture. The Commonwealth Government has appointed an independent panel to review the integrity of ACCUs, particularly regarding the integrity of the human-induced regeneration, avoided deforestation, landfill gas and carbon capture and storage methods. This is because the amount of the ACCUs issued is dominated by three types of projects: avoided deforestation in western NSW; human-induced regeneration of native forests in the dry rangelands of Queensland, New South Wales, Western Australia, South Australia and the Northern Territory; and the combustion of methane from landfills. These projects account for around 75% of the ACCUs issued.[1429] The independent review concluded this carbon credit system is essentially sound. The Commonwealth Government's Climate Change and Energy Minister, the Hon Chris Bowen, mentioned that the Government would implement all 16 of the recommendations that the independent panel developed. This indicates that the vegetation method in Victoria is likely to remain a minimal net contributor of the fund in the future.

1426. Australian Government Clean Energy Regulator, 'About the emissions reduction fund', https://www.cleanenergyregulator.gov.au/ERF/About-the-Emissions-Reduction-Fund Accessed 28 September 2022.

1427. Ibid.

1428. Australian Government Clean Energy Regulator, 'Vegetation methods', https://www.cleanenergyregulator.gov.au/ERF/Choosing-a-project-type/Opportunities-for-the-land-sector/Vegetation-methods Accessed 20 April 2023.

1429. Australian National University 2022, 'Australia's carbon market a 'fraud on the environment', https://law.anu.edu.au/news-and-events/news/australia%E2%80%99s-carbon-market-fraud-environment Accessed 20 April 2023.

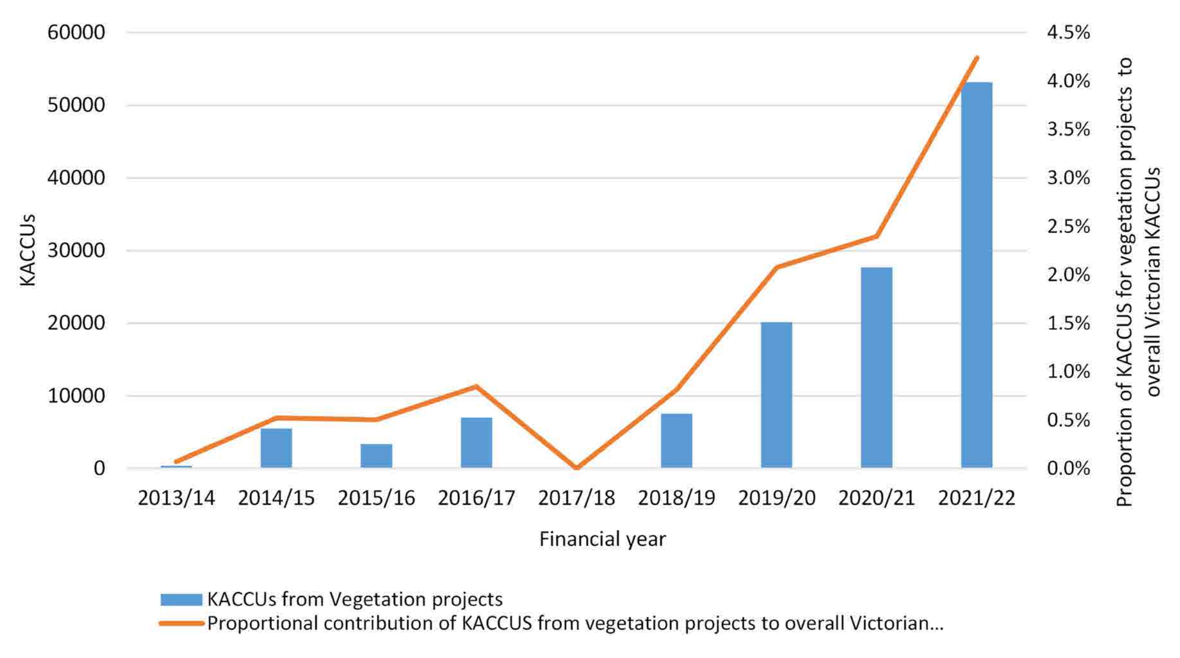


Figure Fo27: Emissions Reduction Fund register in Victoria for vegetation projects by units (Kyoto ACCUs) and proportion to overall units between 2013-14 and 2021-22.[1430]

Productive capacity

Many communities are directly, or indirectly, related to a wide range of forest-based goods and services. The Montreal Process states that productive capacity of the forest is a service that should be monitored to minimise the risk of ecosystem decline and collapse. For forests to be sustainable in this regard, it is necessary to understand the levels at which goods and services may be extracted or used without undermining the functioning of forest ecosystems and processes. For this sub-theme, various aspects of productivity are assessed that are critically important including the area and percent of forest and net area of forest available, the area of native forest harvested, annual production of wood products and the successful regeneration of areas previously harvested.

[1430] Australian Government Clean Energy Regulator, 'Emissions reduction fund register', https://www.cleanenergyregulator.gov.au/DocumentAssets/Pages/Emissions-Reduction-Fund-Register.aspx Accessed 28 September 2022.

Indicator Fo:12 Area and percentage of forest and net area of forest available and suitable for wood production

Fo:12 Area and percentage of forest and net area of forest available and suitable for wood production						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🟡	↙	🟢	🔴	↙	🟢
Data source(s):	DJPR					
Measure(s):	Area and percentage of forest Net area of forest available and suitable for wood productiona					

Why this indicator?

This indicator represents the area available for timber harvesting over time. It provides important information on forest zoning. An increase or decline in area does not necessarily indicate a change in productive capacity as the Victorian Government reflects on growing demand for more protection of forests from timber harvesting to improve other forest values.

Why this assessment in 2023?

The area available for timber harvesting is decreasing. This is the result of the Victorian Government's effort to protect more areas from timber harvesting to improve other forest values, and to acknowledge the impact of the 2019–20 bushfires.

The impact of the 2019–20 bushfires on the area available for timber harvesting was also reviewed by the Major Event Review of the RFAs. It was found that, as a result of 2019–20 bushfires, the D+ operable inventory reduced the level of flexibility in scheduling areas for harvest to 2030, particularly in East Gippsland. However, the remaining sawlog volumes available under the current Allocation Order appear to be more than sufficient to meet the allowable harvesting levels under the VFP for both ash and mixed species in eastern Victoria. Due to ongoing court and litigation processes, and increasing severe bushfires, the timeline for the VFP to end native timber harvesting was revised from 2030 to 1 January 2024.

Summary of State of the Environment 2018 Report assessment

- The resource outlook (RO) from VicForests has reduced the available timber production area in state forests. The RO defines the volume of hardwood timber products from native forests made available to the market, separating the species groups of timber supply into two groups: ash and mixed species.
- The reduction in availability of sawlog resource in areas such as the Central Highlands of Victoria can be attributed to the effects of fire on the estimates of sustained yield. The trend indicates that less timber production will occur in state forests in the future and more emphasis will instead be on other values, including species conservation and carbon sequestration issues.

Critical data used for the 2023 assessment

- Area available for harvest in native forest
- Insights of current available and suitable D+ sawlog for VicForests after 2019-20 bushfires

2023 assessment

Factors like the area, type, and age classes of forest available for timber production are key planning inputs for determining long-term sustainable timber production rates. Monitoring trends in available forest area assists the forest sector in managing any change that will affect resource availability. It also provides insight into the changing balance of management objectives across the forested landscape.

Not all public forests are available for commercial native timber harvesting. Commercial trees are those large enough, and close enough, to a market to allow them to be harvested. In Victoria, most commercially viable native forests are in the east, including the Central Highlands. Data from VicForests (the Victorian government business responsible for the harvest, commercial sale and regrowing of native timber from state forests) shows that approximately 0.04% of native forests are harvested each year. As a result of the Victorian Government's decision to bring forward the end of native forest logging from 2030 to January 2024, the use of native timber for commercial sale will cease by the end of 2023.

Forests

In 2019, the Victorian Government developed the VFP, a 30-year plan outlining the policy directions for Victorian forest industries and the management of timber resources in state forests. The plan included the phasing out of all public native forest harvesting by 2030. As of November 2019, all existing sawlog customers have had supply agreements negotiated out to 30 June 2024. In accordance with the VFP, volumes to harvest will be 138,000 m^3 between 2020 and 2024. For mixed-species D+ sawlog, harvest volumes are 115,000 m^3 between 2020 and 2024.

As a result of the 2019-20 bushfires, D+ operable inventory has reduced the flexibility in scheduling areas for harvest to 2030. The Major Event Review report has found that there is around 11% reduction of the D+ sawlogs (operable inventory of maximum D+ sawlogs) that were available to VicForests prior to the 2019-20 bushfires.[1431, 1432] The report indicated that the remaining sawlog volumes available under the current Allocation Order appear to be more than sufficient to meet the allowable harvesting levels under the VFP for both ash and mixed species in eastern Victoria. As a result of an announcement of bringing forward the end of native timber harvesting by 1 January 2024, concerns towards the reduction of D+ operable inventory to harvest by 2030 will be inapplicable.

Table Fo15 summarises the total available and unavailable area for timber production in both state forests and parks and conservation reserves. It shows that the area that is unavailable for timber production has increased by 400,000 hectares, from 4,648,000 hectares in 2006 to 5,031,000 hectares in 2022. On the other hand, the area available for timber production has decreased by around 370,000 hectares during the same period, from 2,597,000 hectares to 2,229,000 hectares.

Table Fo15: Area available for harvest within native forests of Victoria between 2006 and 2022.[1433]

Tenure	Forest management one	Year and area ('000 ha)							
		2006	2008	2012	2014	2016	2018	2020	2022
Available									
State forest	General Management Zone	2,403	2,318	2,110	2026	2,112	2,180	2,006[a]	2,029[a]
	Special Management Zone	182	172	275	263	159	153	152[a]	200*
Parks and conservation reserves	Limited timber production	12	12	18	14	19	19	0[b]	0[b]
Total available		2,597	2,502	2,403	2,302	2,290	2,352	2,258	2,229
Not Available									
State forest	Special Protection Zone	828	783	753	747	756	768	773	777
	Immediate Protection Area	-	-	-	-	-	0	96[a]	96[a]
Parks and conservation reserves	Limited timber production	-	-	-	-	-	0	19[b]	19[b]
	No timber production	3,820	3,825	3,982	4,117	4,106	4,139	4,130	4,139
Total not available		4,645	4,608	4,735	4,864	4,862	4,907	5,028	5,031
Grand total		7,242	7,110	7,138	7,166	7,153	7,259	7,286	7,260

[a] *In 2019, the Victorian Government developed the VFP. The plan identified IPAs across eastern Victoria which included areas where commercial timber harvesting was previously permitted. The area of GMZ in the IPAs (~89,000 ha), and the area of SMZ in the IPAs (~7,000 ha), has not been included in the area available for harvest.*

[b] *The areas of limited timber production are forest areas where previous land-use determinations (e.g. by the Land Conservation Council) outlined that limited timber production is permitted in these areas, usually with conditions and with the permission of the land manager. While the land-use determinations are still in place these areas were not included in the Allocation Order 2013 (amended in 2014 and 2019). These areas have not been included in the tally of area available for timber production. These areas include: Ada River sawmills historic reserve, Colquhoun regional park, Comet Sawmill historic reserve, Grant historic area, Kirchubels tramway and mill historic reserve, Kurth Kiln regional park, Mississippi no. 1 mill historic reserve, Mount Murphy historic area, Mount murphy historic area, Mount Wills historic area, Rubicon Valley historic reserve, and Walhalla historic area.*

1431. Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.
1432. D+ sawlog is inclusive of B grade, C grade and D grade sawlog.
1433. Department of Jobs, Precincts and Regions (DJPR), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Forests

Indicator Fo:13 Area of native forest harvested

Fo:13 Area of native forest harvested

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	→	🟢	🟡	→	🟢
Data source(s):	DJPR					
Measure(s):	Area harvested under the 5-year harvest-area limits Harvest regimes applied for native timber harvesting and their impact on conservation of threatened species					

Why this indicator?

This indicator assesses the sustainability of harvest levels and the effects of changes to harvest regimes on other forest values, such as biodiversity.

Why this assessment in 2023?

Area of native forest harvested has been stable. The area of native forest harvested is within the 5-year harvest-area limit. Following the 2019–20 bushfires, VicForests introduced a variable retention harvesting system to address concerns about the impact on biodiversity from timber harvesting. As a result, most areas harvested had this system applied. The Victorian Government's decision to bring forward the end of native timber logging to 1 January 2024 and provide support packages for timber workers, sawmill operators and related communities will help to address concerns about biodiversity conservation.

One major difference in native timber harvesting between eastern and western Victoria is related to the application of pre-harvest surveys. In eastern Victoria, the Forest Protection Survey Program has a set target that at least 64% of coupes planned for harvest are to be surveyed. In western Victoria, most coupes are of a silviculture type (e.g. single tree selection, thinning from below, fallen firewood collection), so they have not triggered any survey requirements, such as thinning coupes in the foothill forests of the Midlands/Otways, as they are already meeting basal retention requirements for native species like gliders. Coupes with more intensive silviculture, such as clearfell/seedtree and gap selection, have been restricted to the Mount Cole area, where spotlight surveys were done in 2021 to determine the presence of brush-tailed phascogales prior to the most recent operations. In addition, informal surveys for the Mount Cole grevillia have also been undertaken that targeted areas of likelihood for this species (roadsides and previously disturbed areas).

Summary of State of the Environment 2018 Report assessment

- The area of harvest is below the 5-year harvest-area limits specified in the Allocation Order.
- The area of state forest harvested between 2011–12 and 2016–17 was between 4,400 and 5,600 hectares per year.
- The average area harvested is less than 1% of the total area available for timber harvesting.

Critical data used for the 2023 assessment

- Allocation Order 2013-14 to 2020-21
- Net area harvested by harvesting regime (ha)

2023 assessment

Monitoring and assessing levels of timber harvest from native forest is an essential part of sustainable forest management. Tracking annual harvest rates in native forests against the available level of harvest rate is important for evaluating whether the current approach is sustainable.

Victorian Forestry Plan

In 2019, the Victorian Government developed the VFP, a 30-year plan outlines the policy directions for Victorian forest industries and the management of timber resources in state forests. The plan includes the phasing out of all public native forest harvesting by 2030.

End of native timber harvesting

In 2023, the Victorian Government has decided to bring forward the timeline for ending native timber harvesting from 2030 to 1 January 2024, meaning that there will be no native forest area harvested from 2024 onwards.[1434] The decision was based on the ongoing court and litigation process and the increasing risk of severe bushfires as experienced from 2019-20 bushfires. The Government will provide $200 million of support to workers and their families to transition away from native timber harvesting earlier than planned. Together, with the additional support, the Government's total support for this transition is around $875 million.

Allocation Order

The mechanism that defines the maximum harvest levels for public native forests in Victoria is the Allocation Order 2013 which was later reviewed and amended by the then Ministers for Agriculture in 2014 and again in 2019. The Allocation Order was created under Section 13 of the Sustainable Forests Act. The Allocation Order describes the location and extent of timber resources allocated to VicForests for harvest and sale. Clause 6 of the Allocation Order outlines the total area harvested (ha) must not exceed the five-year harvest-area limits specified in the order. All of western Victoria does not have an Allocation Order and operates mostly under a forest produce licence. This means that the Allocation Order does not include any VicForests coupes in western Victoria.

Special Audit

On 6 December 2019, Victoria's Chief CR released the Special Audit: Assessment of VicForests' Harvesting Activities Against the Allocation Order (the Special Audit).[1435]

The report indicates that the Special Audit was undertaken in response to the allegations aired by an ABC investigation in November 2018. On 21 November 2018, an ABC online article and the ABC 7:30 news program reported that thousands of hectares of state forest appear to have been, or were to be, illegally harvested.

The Special Audit includes the following findings:

- A total of 112.4 hectares were harvested outside the allocated area of the Allocation Order. There is a total of 201 coupes under the TRP (gazetted on 5 January 2017) with area outside the allocated area.
- The Special Audit explains that it is of the opinion that there is insufficient evidence to prove illegal harvesting due to the limitations of the map in the Allocation Order (prior to the April 2019 Allocation Order amendment).
- On 24 April 2019, the then Minister for Agriculture amended the Allocation Order. The amended Allocation Order addresses the issues identified by the Special Audit.

The Allocation Area tallied towards the five-year harvest-area limits

Clause 6 of the Allocation Order states that the total area harvested (ha) must not exceed the five-year harvest-area limits specified in the order. The allocation area (ha) tallied against the harvest-area limits specified in the Allocation Order for the years 2013-14 to 2017-18 is shown in Table Fo16. This period is the first five-year period since the introduction of the Allocation Order. This method for calculating the five-year harvest-area limit began with the Allocation to VicForests (Amendment) Order 2010 in May 2010. In this context, the 'total area harvested' is not net harvest area.

[1434] Premier of Victoria, 'Delivering certainty for timber workers', Melbourne, Victoria, Delivering Certainty For Timber Workers | Premier of Victoria Accessed 24 May 2023.

[1435] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Special audit: Assessment of VicForests' harvesting activities against the Allocation Order', Melbourne, Victoria, https://www.forestsandreserves.vic.gov.au/__data/assets/pdf_file/0027/443826/Special-Audit-Report.pdf Accessed 17 August 2022.

Table Fo16: The allocation area tallied against the harvest-area limits specified in the Allocation Order from 2013-14 to 2017-18.[1436]

	Year							
Forest stand type	2013-14 (ha)	2014-15 (ha)	2015-16 (ha)	2016-17 (ha)	2017-18 (ha)	Total (ha)	Five-year harvest-area limits	Percent allocation area tallied to five-year harvest-area limits
Ash	2090	2273	2583	2386	1988	11,319	14,200	80%
Mixed species	2034	2820	2847	3003	3638	14,344	70,000	20%

The allocation area (ha) tallied against the harvest-area limits specified in the Allocation Order, for the years 2018 -19 to 2022-23 is shown in Table Fo17. This time-period is the second five-year period of the Allocation Order. (Note: only results for the years 2018-19 to 2020-21 (three years) are available.). As a result of the Victorian Government's decision to bring forward the timelines for ending native timber logging, harvesting of native timber will cease as of 1 January 2024, meaning that 2023-24 will be the last financial year that the logging will occur.

Table Fo17: The allocation area tallied against the harvest-area limits specified in the Allocation Order from 2018-19 to 2021-22.[1437]

	Year							
Forest stand type	2013-14 (ha)	2014-15 (ha)	2015-16 (ha)	2016-17 (ha)	2017-18 (ha)	Total (ha)	Five-year harvest-area limits	Percent allocation area tallied to five-year harvest-area limits
Ash	1,650	1,900	2,100	N/A	N/A	5,650	13,700	42
Mixed species	3,000	2,950	3,300	N/A	N/A	9,250	70,500	13

Harvest area

There have been significant changes to the harvest systems used by VicForests during the SoE 2023 reporting period. Since July 2019, VicForests have been using variable retention harvesting in a majority of coupes (Table Fo7). The increased use of variable retention has resulted in the decreased use of clear-felling and seed tree retention harvesting (a type of intensive silviculture with retention). This change is to incorporate previous, long-term silvicultural research findings from Victoria and Tasmania and adopt a more adaptive approach that better protects a broad range of forest values, including retaining habitat trees and cohorts of potential habitat trees.

Following the 2019-20 bushfires, the CR was of the view that the precautionary principle under Section 2.2.2.2 of the Code of Practice for Timber Production 2014 had been triggered. The CR identified 34 species of concern that it advised would require additional precautionary protection from timber harvesting to assist their recovery. The giant burrowing frog, greater glider, glossy black-cockatoo, Leadbeater's possum and the diamond python were among the 34 species requiring additional precautionary protection.[1438] VicForests developed an approach to protect the identified species of concern.

[1436] VicForests 2018, 'Annual harvesting and regeneration report 2017/18', Melbourne, Victoria, https://www.vicforests.com.au/static/uploads/files/vicforests-annual-harvesting-regeneration-report-2017-18-wfwupecflhca.pdf Accessed 4 May 2023.

[1437] Department of Jobs, Precincts and Regions (DJPR), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

[1438] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

Forests

Table Fo18 (supported by information provided in Table Fo19) demonstrates both the areas under the Allocation Order as well as all of the areas in western Victoria having small-scale, relatively low-intensity timber harvesting operations. One major difference between eastern and western Victoria native timber harvesting is the requirement for pre-harvest surveys. VicForests advised that any values that are found during operations are treated as per the requirements of the Code of Practice for Timber Production 2014 (as amended 2022) Schedule 1: Management Standards and Procedures for timber harvesting operations in Victoria's state forests. No formal risk assessment is done and the need for surveys is determined according to need, as determined by the forest type and silviculture type, and if values are identified in the Coupe Management Issues. In eastern Victoria, the Forest Protection Survey Program has a set target of at least 64% of coupes planned for harvest are to be surveyed, whereas in western Victoria, most coupes are of a silviculture type that have not triggered any survey requirements (e.g. single tree selection, thinning from below, fallen firewood collection) as these coupes (e.g. thinning coupes in the foothill forests of the Midlands/Otways) already meet the basal retention requirements for species like gliders. Coupes with more intensive silviculture, such as clearfell/seedtree and gap selection, have been restricted to the Mount Cole area. For the most recent operation in the Mount Cole area, spotlight surveys searching for the presence of the brush tailed phascogale were undertaken in 2021. In addition, informal surveys for the Mount Cole grevilia which targeted areas of likelihood (roadsides and other previously disturbed areas) were also undertaken.

Table Fo18: Net area harvested by harvesting regime in Victoria between 2011-12 and 2020-21.[1439]

Year	Clear-felling (ha)	Fire salvage clear-felling (ha)	Intensive silviculture with retention (ha)	Variable retention (ha)	Selection (ha)	Other (ha)	Commercial thinning (ha)	Total area harvested (ha)
2011-12	1,400	100	2,200	-	700	-	1,200	5,600
2012-13	1,500	-	1,400	-	800	-	1,800	5,500
2013-14	1,300	-	1,400	-	500	-	1,200	4,800
2014-15	1,300	-	1,700	-	400	-	1,000	4,400
2015-16	1,100	-	1,700	-	300	-	1,700	4,800
2016-17	851	12	1,814	0	245	47	1,886	4,855
2017-18	706	0	2,351	0	234	237	1,835	5,363
2018-19	614	0	1,954	0	469	52	1,126	4,215
2019-20	204	0	851	1,043	199	4	1,189	3,491
2020-21	42	128	500	2,238	113	200	675	3,894

Note: Figures of timber harvesting within western Victoria are from areas where most of the Timber Utilisation Plan applies.

[1439] VicForests, 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Table Fo19: Definitions of silvicultural systems for Table Fo18.[1440]

Term	Definition
Clear-felling	A native forest silvicultural system in which all (or nearly all) of the trees in an area are harvested in one operation, such that more than half of the harvested area is greater than one tree height from a retained forest edge. Clear-felling is generally used in native forest types dominated by shade-intolerant tree species.
Fire-salvage clear-felling	Clear-felling following a disaster event. Disaster events can include areas of forests burnt by bushfire, blown over by wind/storms, and killed or damaged by pests or disease.
Intensive silviculture with retention	A range of silvicultural systems including seed-tree and/or habitat-tree retention and alternate coupe harvesting.
Variable retention	A native forest silvicultural system alternative to clear-felling that is designed to meet both harvest objectives and ecological objectives through the retention of trees within an area planned for harvest, with the amount and configuration of retention dependent upon the silvicultural objectives for the stand.
Selection	A native forest silvicultural system in which trees (typically those of a specified size or growth stage) are removed singly or in groups, while other trees (such as regrowth, saplings, pole stems or habitat trees) are retained. Generally used in uneven-aged stands.
Commercial thinning	Harvesting of smaller trees from a forest stand within the rotation to promote more rapid growth of final crop tree, and in which part or all the felled trees are used for commercial purposes to defray part of all of the cost of the operation.

Note: The harvesting systems described in this table are independent of the forest structure.

[1440] VicForests, 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Indicator Fo:14 Annual production of wood products from state forests compared to sustainable harvest levels

Fo:14 Annual production of wood products from state forests compared to sustainable harvest levels

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟢 (wood products) ● (firewood)	↙ (wood products) ↙ (firewood)	🟢 (wood products) 🟡 (firewood)	🟡	↙	🟢
Data source(s):	VicForests					
Measure(s):	Annual production of wood products from state forests					

Why this indicator?

This indicator measures the harvest level of wood products for sustainable forest management in terms of total volumes and sustainable yields by major product group (wood products and firewood).

Why this assessment in 2023?

Total timber annual production from state forests has been decreasing. This is in line with the VFP to phase out native timber production by 2030. The volume of wood production for sawlogs appears to be below the maximum harvest levels. Commercial firewood production has been increasing due to strong demand and VicForests anticipates that this trend will continue. Based on the strong demand for commercial firewood, domestic firewood demand may also be strong; however, due to unavailability of data, the status of the volume of domestic firewood production is unknown.

Total wood production has sufficient information to assess status; however, information needs to be collected for domestic firewood to fully assess the status of firewood production.

Summary of State of the Environment 2018 Report assessment

- Total timber annual production from state forests has been gradually decreasing. Declining sawlog production has continued over the past 20 years. Production fell by more than 50% between 1996-97 and 2016-17. Pulpwood has also followed a similar trend. This will deteriorate further, as age class distribution of ash forests are highly imbalanced.
- The available ash D+ sawlog volume is expected to be reduced between 2020–21 and 2029–30 to 132,000 m^3 per annum. The RO forecasts a consistent supply in the range of 100,000 m^3 until 2029–30 for mixed-species D+ sawlog. The reduction in ash D+ sawlog will be approximately 90,000 m^3 per annum compared to the 2013 RO.
- Sustainable harvest levels have been more than halved over the past decade. A 2017 VEAC report showing modelling of predicted climate change impacts suggests that, by the end of the century, standing volume and stand density will be reduced by 15%. This would further reduce the RO.
- In eastern Victoria, where most commercial native-timber harvesting takes place, most forest stands have regenerated from the 1939 bushfires. However, impacts of the 2009 fires intensified the imbalance of age-class distribution of ash forests in eastern Victoria. As the Victorian sawlog industry currently relies heavily on the 1939 regrowth ash forests, this will cause a significant decrease of available sawlog production from native forests for a few decades.

Critical data used for the 2023 assessment

- Annual production of wood products from state forests (1996–97 to 2020–21)
- Commercial firewood actual harvest volumes from public native forest (2001-02 to 2020-21)

2023 assessment

Of the 7.9 million hectares of Crown Land in Victoria, about 3.7 million hectares are listed as national parks and reserves, and 3.2 million hectares as multi-use state forest, which includes timber harvesting.

The Sustainable Forests Act provides a framework for sustainable forest management and sustainable timber harvesting in state forests. Among other things, the Act:

- provides for the allocation of timber to VicForests through an Allocation Order
- provides for the development of a sustainability charter for Victoria's state forests
- determines the sustainability criteria, indicators and reporting requirements
- establishes the requirement to comply with codes of practice.

The Minister for Agriculture allocates timber resources in state forest to VicForests for harvesting and sale through an Allocation Order. The Allocation Order describes the location and extent of forest stands within state forests to which VicForests has access, the maximum area available for timber harvesting in any five-year period, any additional activities that VicForests is allowed to undertake, and a number of conditions VicForests must comply with in carrying out its functions under the Allocation Order. VicForests may only harvest and/or sell vested timber resources in accordance with the Allocation Order.

VicForests determines how much sawlog timber (both ash and mixed species) is likely to be able to be commercially supplied from the state forests of eastern Victoria in the medium term. ROs are prepared for both ash and mixed species timbers.

Under the *Forests (Wood Pulp Agreement) Act 1996*, there is a minimum supply of 350,000 m^3 of pulpwood (at least 300,000 m^3 per annum from ash forests) that is to be made available to Opal Australian Paper's Maryvale mill until 2030. The VFP does not change the pulpwood supply commitments.

Table Fo20 indicates that total timber annual production from state forests and the production rate for all types of wood products have been decreasing. This trend is a continuation that was found in the SoE 2018 Report. The VFP indicates that all public native forest harvesting will be phased out by 1 January 2024. This means that this trend will be accelerated and discontinue any production of timber harvesting by 1 January 2024.

Forests

Table Fo20: Annual production of wood products from state forests in Victoria between 1996–97 and 2020–21.[1441]

Year	Volume (m^3)			
	Sawlogs a	Pulpwood	Other products b	Total
1996–97	729,000	1,033,000	NA	1,762,000
1997–98	804,000	1,120,000	NA	1,924,000
1998–99	821,000	1,165,000	NA	1,986,000
1999–2000	820,000	1,403,000	NA	2,223,000
2000–01	667,000	1,580,000	NA	2,247,000
2001–02	682,000	1,365,000	111,000	2,158,000
2002–03	638,000	1,208,000	117,000	1,963,000
2003–04	530,000C	1,291,000	112,000	1,933,000
2004–05	583,000 [d, e]	1,335,000	123,000	2,041,000
2005–06	497,000 [d, f]	1,329,000	109,000	1,935,000
2006–07 [g]	428,000	1,241,000	124,000	1,793,000
2007–08	433,000	1,478,000	147,000	2,058,000
2008–09	413,000	1,141,000	158,000	1,712,000
2009–10	443,000	1,250,000	172,000	1,865,000
2010–11	329,525	1,210,024	213,600	1,753,149
2011–12	290,546	980,889	182,503	1,453,938
2012–13	332,054	750,633	189,574	1,272,261
2013–14	304,651	756,425	209,742	1,270,818
2014–15	306,672	758,858	241,205	1,306,735
2015–16	344,746	685,612	285,305	1,315,663
2016–17	299,740	703,730	260,901	1,264,371
2017-18	266,482	706,784	176,029	1,149,295
2018-19	232,629	625,395	185,373	1,043,397
2019-20	201,107	540,913	152,051	894,071
2020-21	202,826	501,918	177,266	882,010

[a] *Prior to 2004–05, sawlog volume is expressed as net volume (gross volume minus allowances for defects).*

[b] *Other products include E-grade (low grade) logs and cull logs. Data not available before 2001–02.*

[c] *Includes 118,000 m^3 fire salvage, normal harvest was 412,000 m^3.*

[d] *Gross sawlog volume.*

[e] *Includes 50,000 m^3 fire salvage, normal harvest was 533,000 m^3.*

[f] *Includes 27,000 m^3 fire salvage, normal harvest was 470,000 m^3.*

[g] *Over the six-year period (2006–07 to 2011–12) approximately 650,000 m^3 of D+ sawlog was harvested from areas burnt by fire.*

[1441] VicForests, 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Sawlog

Prior to the 2019-20 bushfires, VicForests regularly published a RO report with modelled future supply scenarios. The VicForests 2017 RO modelled a future supply scenario and also calculated an expected reduction to available volumes due to expected regulatory restrictions (e.g. areas being made unavailable for timber harvesting for Leadbeater's possum protection). This was used to establish the annual volume of sawlog hardwood timber (D+) that could be commercially supplied from state forests in eastern Victoria. VicForests, the current manager of commercial timber harvesting in Victoria's state forest, continually reviews the future timber availability from the area allocated to it. The 2017 outlook shows a medium-term RO of 132,000 cubic meters per annum for ash D+ sawlog and 100,000 cubic meters per annum for mixed species D+ sawlog.

The 2019-20 bushfires had an immediate impact on the operable sawlog inventory of VicForests. The Major Event Review report found that there is a reduction of the volume of D+ grade sawlog available for harvest into the future by up to 9% in ash forests and up to 13% in mixed species forests.[1442] This means that around 1 million m^3 of D+ standing potential sawlogs were burnt or destroyed by the bushfires (36% ash sawlogs and 64% mixed species sawlogs).

As part of the modernised RFA, the Victorian Government conducted a review of harvest levels.[1443] The outcome of the Harvest Level Review is that, after considering the bushfire impacts on the available timber volume in eastern Victoria, the annual timber supply commitments can still be met and ecologically sustainable forest management supported. The review found that the maximum potential harvest levels for D+ sawlog are 172,000 m^3 per financial year for ash and 144,000 m^3 per financial year for mixed species. It should be noted that the reviews are not a forecast of the volumes that will be made available for future harvest and sale, rather, the volume estimations are more of a 'theoretical' calculation.

Firewood

Firewood is an important energy source for heating and cooking in Victoria. Collection of firewood is allowed to occur in state forests for domestic use but is restricted to designated areas and specific times of the year. Commercial firewood can also be collected by licence holders which ultimately ends up for domestic use.

In September 2011, the licence system for domestic firewood collection was discontinued, but licences are still required for commercial collection. Because of the discontinuation of domestic licenses, the amount of domestic firewood collected in state forests after 2011–12 is unknown. Demand for commercial firewood has been strong and increasing over the last decade since 2010-11, with sales in 2020-21 being nine times higher than the volume in 2020-11 (Table Fo21). VicForests expect that the demand for firewood will remain strong and increase further into the future.[1444]

[1442] Department of Jobs, Precincts and Regions (DJPR) 2021, 'Harvest level in Victorian regional forest agreement regions', Melbourne, Victoria, https://djpr.vic.gov.au/__data/assets/pdf_file/0016/2051431/Harvest-Level-in-Victorian-RFA-regions_Final-Report.pdf Accessed 18 August 2022.

[1443] Ibid.

[1444] VicForests 2021, 'Annual Report 2020-21', Melbourne Victoria, https://www.vicforests.com.au/static/uploads/files/vf-annual-report-2021-final-161121-wfdkuowjlnpm.pdf Accessed 18 August 2022.

Table Fo21: Actual firewood harvest volumes from public native forests in Victoria from 2001-02 to 2020-21.[1445]

Year	Domestic (m^3)	Commercial (m^3)	Total (m^3)
2001–02	48,207	12,256	60,463
2002–03	54,826	16,022	70,848
2003–04	54,454	18,736	73,190
2004–05	56,660	26,980	83,640
2005–06	51,330	14,149	65,479
2006–07	35,926	9,061	44,987
2007–08	24,484	12,184	36,668
2008–09	24,365	12,530	36,895
2009–10	33,645	8,348	41,993
2010–11	38,981	6,106	45,087
2011–12*	11,652	6,400	11,747
2012–13	N/A	18,165	18,165
2013–14	N/A	14,979	14,979
2014–15	N/A	26,041	26,041
2015–16	N/A	31,971	31,971
2016–17	N/A	35,720	35,720
2017-18	N/A	47,227	47,227
2018-19	N/A	46,227	46,227
2019-20	N/A	47,329	47,329
2020-21	N/A	56,471	56,471

Salvage timber harvesting

Victoria has a long history of conducting salvage timber harvesting operations in forests that have been affected by major bushfires.[1446] The Code of Practice for Timber Production 2014 contains rules relating to how salvage harvesting is conducted. As a result of the 2019-20 bushfires, VicForests salvaged a total of 183,831 m^3 of pulp logs in conjunction with the sawlog salvage operations, which resulted in the harvesting of 57,377 m^3 of D+ sawlogs up to the end of June 2021.[1447] In addition to the salvaged D+ sawlogs and pulp logs, VicForests also salvaged 119,801 m^3 of low quality burnt timber which was sold as E grade sawlogs or firewood.

[1445] VicForests, 'Unpublished data', Melbourne, Victoria, Accessed 2022.

[1446] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

[1447] Ibid.

Indicator Fo:15 Proportion of timber harvest area successfully regenerated by forest type

Fo:15 Proportion of timber harvest area successfully regenerated by forest type						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🔴	↙	🟡	🟡	→	🟢

Data source(s):	DJPR, VicForests
Measure(s):	Regeneration success for the period between 1990 and 2004 Outline of forest area (pre-seed age/pre-mature) at risk from future bushfire Estimate of area burnt but not resown Summary of VicForests' post-harvest regeneration success

Why this indicator?

This indicator measures the productive capacity of forest ecosystems in the state. All forest areas where harvesting was undertaken should be regenerated.

Why this assessment in 2023?

Reports found that there is 17,561 hectares of the potential backlog regeneration area among the areas harvested before 2004. The regeneration status of this area will not be known until an assessment is completed by DEECA. The Major Event Review report found that there is still about 4,000 hectares of logged forest for which regeneration operations are still active, even though they were harvested four and five years ago. DJPR advised that they recently began regeneration stocking surveys for bushfire-impacted coupes that were previously regenerated, still regenerating and recently harvested.

DEECA, in partnership with various agencies, recently resowed fire-killed young ash forests for areas that were previously regenerated after timber harvesting and naturally regenerated after previous bushfires. However, the inability to resow the 8,380 hectares of young, fire-killed ash forests due to a lack of seed stock could result in a shift to different vegetation types.

Large areas of previously regenerated, still-regenerating and recently harvested coupes were impacted by the 2019–20 bushfires. It is possible that more coupes will be impacted by fire events as a result of rapidly changing fire regimes (more frequent and higher intensity bushfires). Although there was a revised timeline of VFP from 2030 to 2024, ongoing management of these areas to successfully regenerate remains a priority.

Data are sufficient to assess status and trend, but additional information on the impact of bushfires, particularly the impact of the 2019–20 bushfires, on mixed-species forest coupes that were successfully regenerated would improve data confidence.

Summary of State of the Environment 2018 Report assessment

- Between 2011 and 2017, 2,059 hectares more have been harvested than regenerated. However, according to DJPR, this does not indicate that sustainable harvest has not been achieved. This needs to be carefully monitored to ensure successful post-harvest timber harvest is fully achieved.
- A Victorian Auditor-General's Office (VAGO) 2013 audit report found that the harvest manager, VicForests, was meeting the required regeneration standards, but recommended better alignment of harvesting and regeneration reports.

Critical data used for the 2023 assessment

- Impact of 2019-20 bushfires on previously regenerated areas
- Time series information on progress in regeneration by RFA region

2023 assessment

Following commercial timber harvest, the harvest manager is required to regenerate the harvested area so it returns to approximately its pre-harvest condition. Successful post-harvest regeneration is usually achieved at the first attempt (85% to 95% of the time).[1448, 1449, 1450, 1451] Failure in regeneration can be due to a range of environmental factors, including death from drought, browsing of seed or seedlings (e.g. by wallabies or insects), or frost and snow damage. For areas that have not successfully regenerated the first time, the harvest manager is required to undertake further remedial treatments until the minimum regeneration standards are met. The responsibility of the harvested area by the harvest manager ends when the minimum regeneration standards have been met, after this the land manager takes over sole responsibility.

The current regeneration standards in the Victorian Code of Practice specify regeneration success is measured between 15 to 36 months after planting.[1452] So, regeneration success measured this year is likely to be for forest harvested some 18 to 48 months ago. It is important to note, however, that planting may not occur until 12 months after harvest — usually the next winter following harvest. The time lag between the time of harvest and regeneration success is greater again if additional remedial treatments are required.

Young forest stands are susceptible to fire damage in that they cannot regenerate naturally (on their own). until they are old enough to produce adequate quantities of viable seed. The age at which a forest can produce seed is species dependant but is generally greater than 20 years. DJPR advised that the 2019-20 bushfires impacted regeneration of harvested areas in eastern Victoria, especially East Gippsland. Coupes that were previously successful regenerated, still regenerating and recently harvested were burnt between December 2019 and March 2020. DJPR indicated that they recently began regeneration stocking surveys.

Previously regenerated forests

Before 2004, the Victorian Government was responsible for any backlog in the regeneration of previously harvested forests in Victoria. In 2004, the responsible department of these harvested areas where regeneration was unsuccessful was the Department of Sustainability and Environment (DSE). The responsibility for pre-2004 regeneration transferred from DSE to the Department of Environment and Primary Industries (DEPI) in 2011 and then to subsequent departments. Since 2004, VicForests has been responsible for the regeneration in public forests after timber harvesting operations that occurred after 2004. As part of this, VicForests must submit an annual Allocation Order report to the Secretary of DJPR each year which provides information on the area of timber harvested and regenerated for both ash and mixed species forest stands for the proceeding financial year.

VAGO's 2013 audit of the regeneration performance for areas harvested before 2004 (about 37,000 ha) found that the regeneration status of these areas was uncertain and that potentially 5,500 hectares to 7,000 hectares of the harvested area may not have been successfully regenerated.[1453] In 2018, VAGO tabled its follow-up report to the 2013 audit which stated that DEPI had refined its estimate of the potential regeneration backlog to 27,400 hectares and assessed the regeneration status of 9,839 hectares. It was found that around 8,000 hectares was successfully regenerated but it was still unclear how the remaining 1,839 hectares was further treated to complete regeneration.[1454]

1448. Wilson NW, Fagg PC 1994, 'Hardwood coupe regeneration in native state forest (1989/90 – 91/92)', Forests Technical Report No.13 Conservation and Natural Resources, Victoria.
1449. Department of Sustainability and Environment (DSE) 2003, 'Regeneration and reforestation stocking in Victoria's native state forests (1993/94 to 1996/97): Even-aged silviculture'. Forests Service Technical Report 03-1. Melbourne, Victoria.
1450. Murphy S, Fagg PC 1996, 'Regeneration and reforestation stocking in native state forest (1989/90-92/93)', Forests Technical Report 96-1, Department of Natural Resources and Environment, Victoria.
1451. Fagg PC, Meyers ND, Bassett OD 2008, 'Stocking following harvesting and regeneration in Victoria's state forests (1996/97 – 2000/01)', Natural Resources Report Series 08-1. Department of Sustainability and Environment, Melbourne, Victoria.
1452. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Code of practice for timber production 2014 (as amended 2022) schedule 1: Management standards and procedures for timber harvesting operations in Victoria's state forests', Melbourne, Victoria.
1453. Victorian Auditor-General's Office (VAGO) 2013, 'Managing Victoria's native Forest timber resources', pp 27-30, https://www.audit.vic.gov.au/report/managing-victorias-native-forest-timber-resources?section=31106 Accessed 29 March 2021.
1454. Victorian Auditor-General's Office (VAGO) 2018, 'Follow up of selected 2012-13 and 2013-14 performance audits', pp 33-36, https://www.audit.vic.gov.au/report/follow-selected-2012-13-and-2013-14-performance-audits?section= Accessed 16 November 2021.

The Victorian Government now inherited not only the responsibility for regenerating the areas for which DEPI was previously responsible for but also assessing the remaining 17,561 hectares of the potential backlog of the regeneration area.[1455] The 2018 report also found that VicForests successfully regenerated 79% of the 46,616 hectares harvested between 2004 and 2014, which is considered to be acceptable progress given the 3-year lag between harvesting and the completion of regeneration.

As a part of the Major Event Review report, the Independent Panel reviewed the current status of areas previously harvested to confirm successful regeneration following the 2019-20 bushfires. The responsibility for the ongoing management of this previously successfully regenerated area lies with DEECA once they are finalised and removed from the TRP. In terms of ash forest, 82,700 hectares was impacted by the 2019-20 bushfires but there was no information on the impact of the bushfires on mixed-species forest.[1456]

The report also received the data from VicForests that, across the whole of eastern Victoria, 83% of all coupes harvested between 2004-05 and 2019-2020 have been successfully regenerated and finalised. Harvested coupes generally take around three years to complete regeneration activities. For areas harvested four and five years ago, there is still around 40% of about 10,000 hectares of logged forest for which regeneration operations are still active. These areas still remain in the TRP.

A new report co-published by 19 Victorian environmental groups claimed that successful post-harvest regeneration rate within 3 years at first attempts after harvesting is around 70% compared to the 85% to 95% reported by VicForests.[1457] The groups also reported that this rate goes down to 50% for mountain ash forests. They indicated that logged areas where VicForests claimed to be successfully regenerated actually turned into weed-infested blackberry patches and some areas had colonising species that have replaced the original eucalypts. The types and extent of regeneration failure varied, sometimes involving entire coupe, and at other times isolated to confined patches. Their report is based upon field inspections (on-the-ground and drones) of forest coupes across eastern Victoria. However, this evidence requires a validation process to be undertaken by the Victorian Government to investigate further the conflicting findings and communicate with the groups future steps to resolve the issues raised. The Victorian Government has not provided a formal response to these claims but did announce a revised timeline for the VFP from 2030 to 2024 and that there should be ongoing management to successfully regenerate all areas that were previously harvested.

In response to the 2019-20 bushfires, the Victorian Government invested $7.7 million to collect seed and sow areas of young ash forests that were killed by bushfires. This includes both areas previously regenerated after timber harvesting and areas naturally regenerated after previous bushfires. A large-scale reseeding program in some of the fire-affected ash forests identified that 5,665 hectares of ash forests lacked the seed bed receptivity required for successful resowing before there is a change in vegetation type.[1458] The program invested in increasing ash seed stocks capacity from 7,300 kg to 15,800 kg between March and June 2020 in partnership with VicForests.[1459] DEECA used seeds to treat 11,587 hectares of fire-affected immature ash forests. Nevertheless, 8,380 hectares of young fire-killed ash could not be resown due to insufficient ash species seed stock being readily available, which could result in shifting to different vegetation type.[1460]

[1455] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

[1456] Ibid.

[1457] Alberton West Friends of the Forest, BEAM Mitchell Environment Group, Environment East Gippsland (EEG), Environment Victoria, Friends of Bats and Habitat Gippsland, Friends of the Earth - Forest Collective (FOE), Friends of Leadbeaters Possum (FOLP), Friends of Noojees Trees, Gippsland Environment Group, Goongerah Environment Centre (GECO), The Great Tree Project (GTP), Kinglake Friends of the Forest (KFF), Lawyers for Forests, Newlands Friends of the Forest, Rubicon Forest Protection Group (RFPG), Toolangi Forest Protection Group, Victorian National Parks Association (VNPA), Wildlife of the Central Highlands (WOTCH), Warburton Environment (WE) 2021 'After the logging - Failing to regrow Victoria's native forests', https://vnpa.org.au/wp-content/uploads/2021/11/AfterTheLogging_Nov2021.pdf Accessed 13 December 2022.

[1458] Forests Solutions 2021 'Post-fire Ash Forest Recovery-2020: An assessment of the recovery of ash forests burnt during Victoria's 2019/20 Black Summer bushfires, with recommendations for silvicultural intervention and advice regarding forest type-change'. (Unpublished report prepared for DELWP November 2021, provided to the Major Event Review panel).

[1459] Department of Environment, Land, Water and Planning (DELWP), 'Forest restoration project' submitted to the Inspector-General for Emergency Management Inquiry into the 2019–20 Victorian fire season', Unpublished document provided to the Major Event Review Panel.

[1460] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

Forests

Legal, institutional and economic frameworks

Legal, institutional and economic frameworks guide short- and long-term sustainable forest management and conservation. They provide the capacity to monitor change and to conduct and apply research and development. Indicators under this sub-theme describe and contextualise relevant forestry legislation, institutional capacity and economic arrangements. These indicators contribute to raising public and political awareness of issues affecting forests and builds support for their sustainable management.

Indicator Fo:16 Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests

Fo:16 Extent to which the legal framework (laws, regulations, guidelines) supports the conservation and sustainable management of forests

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	↗	●	●	↗	●
Data source(s):	ARV, DELWP, DJCS, DJPR, DPC, DTP, GORCP Authority, PV, VPC					
Measure(s):	Number of pieces of legislation is an appropriate measure of the extent to which a legal framework supports good outcomes					

Why this indicator?

This indicator provides current arrangements of legal framework and changes made for the sustainable management of forests.

Why this assessment in 2023?

The legal framework in Victoria that regulates forest management across the state comprises 58 legislative instruments. Major amendments are related to improved protection of biodiversity, and sustainable and ecological native timber harvesting.

New public land legislation to replace the current *Land Act 1958*, the *Crown Land (Reserves) Act 1978* and the *Forests Act 1958* would be needed to further support the conservation and sustainable management of forests.

The passing of the *Forests Legislation Amendment (Compliance and Enforcement) Act 2021* served to improve the regulation of native timber harvesting for sustainable forest management. The Code of Practice for Timber Production 2014 underwent reform in November 2021 and again in June 2022.

Many pieces of legislation have been amended, and new legislation has been enacted for sustainable forest management.

Summary of State of the Environment 2018 Report assessment

- VEAC provided its Statewide Assessment of Public Land Final Report to government in May 2017, including several recommendations to reform the complex public land legislative framework. The Victorian Government has accepted or accepted in principle or in part all recommendations made by VEAC, including committing to rewriting the Crown Land legislation over the next four years.

Critical data used for the 2023 assessment

- Primary legislative instruments relevant to sustainable forest management in Victoria

2023 assessment

A legal framework with laws, regulations and guidelines is necessary in supporting continuous improvements in sustainable forest management. Such a system assists in establishing transparency and public participation in policy and decision-making processes. The legal framework in Victoria comprises 58 legislative instruments that regulate forest management across Victoria.

Key amendments over the reporting period include:

- Extensive amendments to the FFG Act to provide a modern and strengthened framework for improved protection of Victoria's biodiversity.
- Passage of the *Parks Victoria Act 2018* and the amendment of the National Parks Act and other related legislation to create PV as a statutory body directly charged with the management of Victoria's estate of parks and reserves.
- Amendments to strengthen regulation of timber harvesting operations and other activities in Victoria's forests, including through amendments to the Code of Practice for Timber Production 2014 and passage of the *Forests Legislation Amendment (Compliance and Enforcement) Act 2021.* This was to improve the environmental regulation of timber harvesting

Implementation responsibility for the 58 legislative instruments is spread across nine agencies, corporations and authorities, comprising:

- Alpine Resorts Victoria (ARV)
- Department of Energy, Environment and Climate Action (DEECA)
- Department of Jobs, Skills, Industry and Regions (DJSIR)
- Department of Justice and Community Safety (DJCS)
- Department of Premier and Cabinet (DPC)
- Department of Transport and Planning (DTP)
- Great Ocean Road Coast and Parks (GORCP) Authority
- Parks Victoria (PV)
- Victorian Plantations Corporation (VPC)

Table Fo22 below summarises Victoria's legislative instruments, the tenure to which they apply and lists any key amendments made during the SoE 2023 reporting period.

In 2017, the VEAC recommended that, within five years, state forests should be administered under one act. It also recommended a new public land act to replace the current *Land Act, the Crown Land Act* and the *Forests Act*.[1461] The Victorian Government accepted both recommendations. This was included in the SoE 2018 Report. However, the Victorian Government has still not completed legislation to consolidate these three acts into a new Public Land Act, although consultation was completed in 2021. An engagement report summarising the feedback received was released later that year prior to finalising the policy to guide the development of the new legislation.

Regulating native timber harvesting for sustainable forest management was identified to be improved through further refinements by passing the *Forests Legislation Amendment Act,* which came into force on 1 March 2022. The Code of Practice for Timber Production has also undergone reform in November 2021 and again in June 2022. The recent VAGO report on the CR indicates there are more areas to improve for effective monitoring and enforcing compliances.[1462] DELWP has either accepted or accepted in principle all 10 recommendations made in the report.

[1461] Victorian Environmental Assessment Council (VEAC) 2017, 'Statewide assessment of public land, final report', Melbourne, Victoria, https://www.veac.vic.gov.au/investigations-assessments/previous-investigations/investigation/statewide-assessment-of-public-land Accessed 20 April 2023.

[1462] Victorian Auditor-General's Office (VAGO) 2022, 'Regulating Victoria's native forests', Melbourne, Victoria, https://www.audit.vic.gov.au/report/regulating-victorias-native-forests?section=34232--1-audit-context&show-sections=1#34232--1-audit-context Accessed 10 October 2022.

Table Fo22: Primary legislative instruments relevant to sustainable forest management in Victoria.[1463]

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA	Code of Practice for Timber Production	Provide direction to the managing authority, harvesting entities and operators to deliver sound environmental performance when planning for and conducting commercial timber harvesting operations.	State forest	Amended in November 2021 to: Restore a clear definition of the precautionary principle based on internationally recognised language and reflecting the government's policy intent Codify existing protections for large trees and Watson's tree frog Generally improve the clarity of the Code by addressing a range of deficiencies, errors and omissions. Amended in June 2022 to: Reflect the government's policy intent for specific clauses relating to hollow-bearing trees and long-lived understorey species, protections for the Tree Geebung, and harvesting in fire management zones Move the Management Standards and Procedures for timber harvesting operations in Victoria's state forests 2021 into the Code as a schedule.
DEECA	Code of Practice for Bushfire Management on Public Land	Support DEECA to meet its legislative responsibilities for fire management. Set objectives and strategies for bushfire management on public land. Provide a risk analysis framework. Establish a monitoring, evaluation and reporting framework. Outline actions which will be undertaken during prevention, preparedness, fuel management, response and recovery.	State forests, national parks (including state parks, protected public land	Amended to extend operation of Code to 31 December 2024 and to make minor changes to provide currency of Acts and agency names.
DEECA / ARV	*Alpine Resorts (Management) Act 1997*	To provide a framework for the management of alpine resorts.	Alpine Resorts	NA
DEECA / ARV	Alpine Resorts (Management) Regulations 2020	To provide for the protection, management and control of alpine resorts.	Alpine Resorts	Remade in 2020
DEECA	*Conservation, Forests and Lands Act 1987*	To provide a framework for a land management system and to make necessary administrative, financial and enforcement provisions, and to establish a system of land management co-operative agreements.	Public/Private (where applicable)	The *Forests Legislation Amendment (Compliance and Enforcement) Act 2021* amended the *Conservation, Forests and Lands Act 1987* to provide for mandatory injunctions in certain circumstances, and to make other miscellaneous amendments.

[1463] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA	*Sustainable Forests (Timber) Act 2004*	To provide a framework for sustainable forest management and sustainable timber harvesting in state forests.	State forests	The *Forests Legislation Amendment (Compliance and Enforcement) Act 2021* amended the *Sustainable Forests (Timber) Act 2004* to: • amend the offence relating to unauthorised timber harvesting operations, • clarify the requirement to comply with any relevant Code of Practice, • make further provision for the circumstances in which enforceable undertakings may be entered, • introduce a power for authorised officers to require the production of documents, and • enable the incorporation of documents by reference in certain instruments.
VPC	*Victorian Plantations Corporation Act 1993*	To establish the VPC to manage state plantations and to establish the requirement for timber harvesting to comply with a code of practice.	Land vested in the VPC and Crown land leased to the VPC	NA
VPC	Victorian Plantations Corporation (Register of Plantation Licences) Regulations 2018	To prescribe documents to be registered in the register of plantation licences under the *Victorian Plantations Corporation Act 1993.*	Land vested in the VPC and Crown land leased to the VPC	NA
VPC	*Forests Act 1958*	To provide for the management and protection of state forests, including timber harvesting and fire management.	State forests and all public land for fire matters	The *Parks Victoria Act 2018* amended the *Forests Act 1958* to provide for PV to assume responsibility for the exercise of various functions and powers for any reserved forest for which it is appointed as the land manager. The *Parks and Crown Land Legislation Amendment Act 2020* amended the *Forests Act 1958* to make miscellaneous amendments, including in relation to campfires on licensed water frontages. The *Forests Legislation Amendment (Compliance and Enforcement) Act 2021* amended the *Forests Act 1958* to: • insert an offence prohibiting the cutting or taking of timber in a state forest without authority, • enable the incorporation of documents by reference in certain instruments, and • repeal spent provisions.
DEECA	Forests (Fire Protection) Regulations 2014	To provide for the protection of state forests, national parks and protected public land from damage by fire.	National parks (including state parks), state forests and protected public land	State forests, national parks (and other parks and areas under the *National Parks Act 1975)* and protected public land.

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA	Forests (Recreation) (Temporary) Regulations 2021	To regulate camping and other activities in certain public land state forests including forests reserves and forest parks.	State forests	Remade in 2021.
DEECA	Forests (Domestic Firewood) Regulations 2022	To regulate or prohibit certain conduct in a firewood collection area during a firewood collection season in state forest, and to prescribe offences.	State forests	Remade in 2022.
DEECA	Forests (Licences and Permits) Regulations 2019	To prescribe certain acts which may not be undertaken within a reserved forest without a licence, permit or authority.	Reserved forest	Remade in 2019.
DEECA	Forests (Tour Operator Licence Fee) Regulations 2021	To prescribe the fees payable in respect of tour operator licences granted in respect of Crown land in a reserved forest under the Forests Act 1958, and to provide for the reduction, waiver or refund of tour operator licence fees.	All	Remade in 2021.
DEECA	*Flora and Fauna Guarantee Act 1988* (FFG Act)	To establish a legal and administrative structure to enable and promote the conservation of Victoria's native flora and fauna, and to provide for a choice of procedures which can be used for the conservation, management or control of flora and fauna and the management of potentially threatening processes.	All	*The FFG Act* has been amended to: • introduce principles to guide the implementation of the FFG Act, including consideration of the rights and interests of Traditional Owners and the impacts of climate change • ensure decisions and policies are made with proper consideration of the potential impacts on biodiversity • clarify existing powers to determine critical habitat and improves their protection by encouraging cooperative management • give effect to a consistent national approach to assessing and listing threatened species using the Common Assessment Method, which will reduce duplication of effort between jurisdictions and facilitate the monitoring and reporting of species' conservation status • modernises the FFG Act's enforcement framework including stronger penalties.

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA	*Flora and Fauna Guarantee Amendment Act 2019*	To establish a legal and administrative structure to enable and promote the conservation of Victoria's native flora and fauna, and to provide for a choice of procedures which can be used for the conservation, management or control of flora and fauna and the management of potentially threatening processes.	All	During the reporting period, the *Flora and Fauna Guarantee Amendment Act 2019* made the above amendments to the FFG Act. Amendments came into effect on 1 June 2020.
DEECA	Flora and Fauna Guarantee Regulations 2020	To specify the criteria for determining eligibility for listing under the FFG Act.	All	Remade in 2020 to support amendments made to the FFG Act.
DEECA / GORCP Authority	*Great Ocean Road and Environs Protection Act 2019*	To recognise the importance of the Great Ocean Road and its environs to the economic prosperity and liveability of Victoria for the purposes of protecting that area and to establish the GORCP Authority.	Public land Private land (strategic planning)	Act made.
DEECA	*Catchment and Land Protection Act 1994 (CaLP Act)*	To set up a framework for the integrated management and protection of catchments, to encourage community participation in the management of land and water resources and to set up a system of controls on noxious weeds and pest animals.	All	The *Water and Catchment Legislation Amendment Act 2019* amends the CaLP Act to: • progress objectives in the government's flagship strategic plan for water (i.e. Water for Victoria) • recognise and involve Traditional Owners and Aboriginal Victorians and their cultural values in the planning and management of waterways and catchments, consideration of social and recreational uses of waterways, amongst other policies. The *Water and Catchment Legislation Amendment Act 2021*, implements nine areas of reform to the water sector which include: • greater water market transparency • strengthening powers to regulate, rate and time of take water • integration of Western Water Corporation into City West Water Corporation • transferring the functions, powers, duties and employees of Port Phillip and Westernport Catchment Management Authority (CMA) to Melbourne Water Corporation • ceasing the Victorian Catchment Management Council • broadening the primary producer requirements for CMA Boards • streamlining reporting requirements for CMAs.

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA	*Land Act 1958*	To set out the law relating to the sale and occupation of Crown Land, including provision for a range of licences.	Public land	The *Parks Victoria Act 2018* amended the *Land Act 1958* to provide for Parks Victoria to assume responsibility for the exercise of various functions and powers for any unreserved Crown land for which it is appointed as the land manager. The *Parks and Crown Land Legislation Amendment Act 2020* amended the *Land Act 1958*, including to: • remove the prohibition on camping on licensed water frontages • enable regulations to be made for recreational uses of certain land abutting watercourses
DEECA / PV	Land (Tour Operator Licence Fee) Regulations 2021	To prescribe the fees payable in respect of tour operator licences granted in respect of under reserved *Crown Land under the Land Act 1958*, and to provide for the reduction, waiver or refund of tour operator licence fees.	Public land	Remade in 2021.
DEECA / PV	*National Parks Act 1975*	To provide a framework for establishment and management of national parks and other parks.	National parks and other parks and reserves referred to in the Act	The *Parks Victoria Act 2018* amended the *National Parks Act 1975* to provide for PV to assume responsibility for parks and other areas under the Act. The *Parks and Crown Land Legislation Amendment Act 2020* amended the *National Parks Act 1975* to: • add 3,076 ha of forest to Errinundra National Park • provide for landscape conservation areas and creating the Yellingbo Landscape Conservation Area • to make other miscellaneous amendments
DEECA / PV	National Parks Regulations 2013	To provide for the management and control of parks to promote the preservation and protection of parks, flora, fauna and indigenous fish, the protection of designated water supply catchment areas and other water supply catchment areas; and the safety, enjoyment, recreation and education of visitors to parks.	National parks and other parks and reserves referred to in the Act	NA
DEECA / PV	National Parks (Tour Operator Licence Fee) Regulations 2021	To prescribe the fees payable in respect of tour operator licences granted in respect of parks under the *National Parks Act 1975*, and to provide for the reduction, waiver or refund of tour operator licence fees.	Public land	Remade in 2021.

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA / PV	*Parks Victoria Act 2018*	The purpose of this Act is to re-establish PV. There were major changes to the legislative framework, which resulted in having included a transfer of broad range of direct various functions and powers to PV in relation to the management of Victoria's various parks and metropolitan waterways.	National parks and other parks and other conservation reserves, metropolitan waterways	NA
DEECA	*Environment Protection Act 2017*	To provide for the continuation of the Environment Protection Authority (EPA) Victoria with a new governance structure including a Governing Board to: specify that EPA Victoria's objective is to protect human health and the environment by reducing harm from pollution and waste, set out principles for environment protection provide for a General Environmental Duty and a broad legislative framework to support EPA Victoria's objectives	All	The *Environment Protection Act 2017*, as amended by the *Environment Protection Amendment Act 2018*, came into effect on 1 July 2021. The Act repealed the *Environment Protection Act 1970* and amended the *Public Administration Act 2004* including introducing the general environment duty, and an updated legislative framework for permissions, waste transport and disposal, notifiable incidents (pollution), managing contaminated land, and providing EPA Victoria with stronger sanctions and compliance tools.
DEECA	Environment Protection (EP) Regulations 2021	To support the objectives of the primary legislation (to prevent or minimise risks to human health and the environment from pollution and waste) by giving effect to obligations under the *Environment Protection Act 2017* and providing for a range of matters including exemptions, fees, and the form and manner of applications.	All	NAs.
DEECA	Environment Reference Standard	The Environment Reference Standard sets out the environmental values of the ambient air, ambient sound, land and water environments that are sought to be achieved or maintained in Victoria and standards to support those values.	All	The Environment Reference Standard was made in March 2022.
DTP	*Environment Effects Act 1978*	To provide a framework for assessment of proposed projects (private and public works) with the potential for significant effect on the environment, in particular preparation of an Environment Effects Statement when the Minister for Planning considers it necessary.	All	NA

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA	*Heritage Rivers Act 1992*	To make provision for Victorian heritage rivers by providing for the protection of public land in particular parts of rivers and river catchment areas in Victoria which have significant nature conservation, recreation, scenic or cultural heritage attributes.	Public land	NA
DEECA	*Crown Land (Reserves) Act 1978*	To provide for the reservation of Crown lands for certain purposes and for the management of such reserved lands.	Reserved Crown land	The *Parks Victoria Act 2018* amended the *Crown Land (Reserves) Act 1978* to provide for PV to assume responsibility for the exercise of various functions and powers for any Crown land reserves for which it is appointed as the land manager.
DEECA	Crown Land (Reserves) (Domestic Firewood) Regulations 2022	To regulate or prohibit certain conduct in a firewood collection area during a firewood collection season in certain regional parks and to prescribe offences.	Reserved Crown land	Remade in 2022.
DEECA	Crown Land (Reserves) (Tour Operator Licence Fee) Regulations 2021	To prescribe the fees payable in respect of tour operator licences granted in respect of reserved Crown land under the *Crown Land (Reserves) Act 1978*, and to provide for the reduction, waiver or refund of tour operator licence fees.	Reserved Crown land	Remade in 2021.
DEECA	Crown Land (Reserves) (Nature Conservation Reserves) Regulations 2004	To provide for the care, protection and management of nature conservation reserves.	Nature Conservation Reserves on reserved Crown land	NA
DEECA	*Reference Areas Act 1978*	Provides for the protection, control and management of certain Special Areas of Crown Land to be preserved in their natural state, as far as is possible, due to their ecological interest and significance.	Public land	NA

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DTP	*Planning and Environment Act 1987*	To establish a framework for planning the use, development and protection of land in Victoria in the present and long-term interests of all Victorians, including timber production on private land. Provides for the protection of natural processes and genetic diversity, and to conserve places of scientific, aesthetic or special conservation value.	All	NA
DJCS	*Country Fire Authority Act 1958*	To confer on the Country Fire Authority (CFA) a responsibility to prevent and suppress fire on all land in the country area of Victoria and other areas in certain circumstances, and to require the establishment of forestry industry brigades for landowners in circumstances prescribed by the regulations. Allows the CFA to declare a total fire ban day across the whole or part of Victoria and issue Fire Prevention Notices to landowners (other than a public authority) in the country area of Victoria.	Private	The *Firefighters' Presumptive Rights Compensation and Fire Services Legislation Amendment (Reform) Act 2019* amended the *Country Fire Authority Act 1958* to: • alter the CFA's geographical area of responsibility to cover the country area of Victoria • recognise that the CFA is a fully volunteer fire fighting services under the command and control of a paid Chief Officer and supported where necessary by other paid staff.
DJCS	Country Fire Authority Regulations 2014	To prescribe, among other things, matters relating to the requirements for the formation, registration and operation of forestry industry brigades.	Private	NA
DJCS	*Fire Rescue Victoria Act 1958*	To establish Fire Rescue Victoria and confer upon it a function for fire suppression in the Fire Rescue Victoria fire district, and other areas in certain circumstances.	Private	Amended from the *Metropolitan Fire Brigade Act 1958* to establish Fire Rescue Victoria (FRV), which has responsibilities in relation to the FRV fire district.
DJCS	*Emergency Management Act 2013*	To establish governance arrangements for emergency management in Victoria. Specifically, it legislates the framework for control arrangements for emergencies, including major fires, which impact the sustainable management of forests where an emergency occurs.	All	NA

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA	*Road Management Act 2004*	To establish a coordinated management system for public roads that will promote safe and efficient state and local public road networks and the responsible use of our roads.	Public land	NA
DEECA	*Safety on Public Land Act 2004*	Provides for public safety in state forests by providing for the establishment and enforcement of public safety zones.	State forests	NA
DEECA	*Forests (Wood Pulp Agreement) Act 1996*	To ratify an Agreement between the Minister administering the *Forests Act 1958* and Amcor Limited with respect to the supply of pulpwood for the manufacture of wood pulp and for other purposes.	Public land	NA
DEECA	*Land Conservation (Vehicle Control) Act 1972*	To make provisions for vehicular traffic on public land (via regulations), as well as the prevention of soil erosion on, and damage to, public land.	Public land	NA
DEECA	Land Conservation (Vehicle Control) Regulations 2013	Regulations to prohibit driving of motor vehicles off-road and providing powers to land managers to regulate other vehicles on public land.	Public land	NA
DPC / DEECA	*Aboriginal Lands Act 1991*	To authorise the granting of the reservations and Crown Grants of certain lands for Aboriginal cultural and burial purposes.	Public land	NA
DPC	*Aboriginal Heritage Act 2006*	To provide for the protection and recognition of Aboriginal cultural heritage and Aboriginal intangible heritage in Victoria. Recognises Aboriginal people as the primary guardians of their cultural heritage.	All	The *Aboriginal Heritage Act 2006*, was amended to include if a Registered Aboriginal Party is placed into administration by the Office of thae Registrar of Indigenous Corporations under the *Corporations (Aboriginal and Torres Strait Islander) Act 2006* (Cth) this does not qualify as "administration" for the purpose of s 156(2)(b) of the *Aboriginal Heritage Act 2006*.
DPC	Aboriginal Heritage Regulations 2018	To provide for the development of Cultural Heritage Management Plans for high impact activities, and activities carried out in areas of cultural heritage sensitivity.	All	The new Aboriginal Heritage Regulations 2018 came into effect on 23 May 2018. These replace the *Aboriginal Heritage Regulations 2007* following a review by First Peoples – State Relations.
DJCS	*Traditional Owner Settlement Act 2010*	To provide for the making of negotiated agreements for land claims between Traditional Owner groups and government.	All	NA

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA	*Heritage Act 2017*	To protect and conserve the cultural heritage of the state, including significant places and objects such as extensive land areas, buildings, gardens and trees, and archaeological sites/remains assessed as being of significance at a state level (Victorian Heritage Register), and archaeological sites and approved sites of archaeological value listed on the Victorian Heritage Inventory.	All	The *Heritage Act 2017* replaces (with amendments) the *Heritage Act 1995*.
DEECA	Heritage Regulations 2017	To set fees for certain activities, penalties and infringements offences under the *Heritage Act 2017.*	All	NA
DEECA	*Climate Change Act 2017*	To provide a legislative foundation to manage climate change risks, maximise the opportunities that arise from decisive action, and drive Victoria's transition to a climate-resilient community and economy. The *Climate Change Act 2017* sets out GHG emissions reduction targets and sets out policy objectives and guiding principles to inform decision-making and development of government policy.	All	The *Climate Change Act 2017* repeals and re-enacts (with amendments) the *Climate Change Act 2010* to: • implement changes arising from a statutory review of the *Climate Change Act 2010* • make consequential amendment to the *Environment Protection Act 1970* • respond to climate change through a climate change strategy, adaptation action plans and emissions reduction pledges • provide for greater clarity and accountability through information collection and reporting • facilitate the state's contribution to national and international carbon sequestration efforts • provide for the creation of forestry rights, carbon sequestration rights and soil carbon rights • provide for Forestry and Carbon Management Agreements in relation to private land and Carbon Sequestration Agreements in relation to Crown land.
DEECA	*Marine and Coastal Act 2018*	To provide for co-ordinated strategic planning and management for the Victorian coast and marine environment.	All	Act made

Agency	Legislative instrument	Purpose	Applicable tenure	Key amendments relating to forest management from 2018 to 2022
DEECA	*Water Act 1989*	To provide for the integrated management of all elements of the terrestrial phase of the water cycle and to promote the orderly, equitable and efficient use of water resources.	All	The *Water and Catchment Legislation Amendment Act 2019*, amends the *Water Act 1989* to: • progress objectives in the government's flagship strategic plan for water • recognise/involve Traditional Owners and Aboriginal Victorians and their cultural values in the planning and management of waterways and catchments, consideration of social and recreational uses of waterways, amongst other policies. • The *Water and Catchment Legislation Amendment Act 2021*, implements • nine areas of reform to the water sector including include: • greater water market transparency • strengthening powers to regulate, rate and time of take water • integration of Western Water Corporation into City West Water Corporation • transferring the functions, powers, duties and employees of Port Phillip and Westernport CMA to Melbourne Water Corporation • ceasing the Victorian Catchment Management Council • broadening the primary producer requirements for CMA Boards • streamlining reporting requirements CMAs.
DEECA	*Wildlife Act 1975*	To provide for state wildlife reserves and nature reserves and to establish procedures and provide for banning notices and exclusion orders in order to promote the protection and conservation of wildlife, and the prevention of taxa of wildlife from becoming extinct.	All	The *Parks Victoria Act 2018* amended the *Wildlife Act 1975* to provide for PV to assume responsibility for the exercise of various functions and powers for any state wildlife reserves or nature reserves for which it is appointed as the land manager.
DEECA	Wildlife Regulations 2013	To provide for the management and conservation of wildlife and wildlife habitat, as well as the humane use of and access to wildlife.	All	NA
DEECA	Wildlife (Game) Regulations 2012	To provide for the effective management of game species and game hunting in Victoria across public and private land.	All	NA
DEECA	Wildlife (Tour Operator Licence Fee) Regulations 2021	To prescribe the fees payable in respect of tour operator licences granted in respect of Crown land managed under the *Wildlife Act 1975*, and to provide for the reduction, waiver or refund of tour operator licence fees.	All	NA

Forests

Indicator Fo:17 Extent to which the institutional framework supports the conservation and sustainable

Fo:17 Extent to which the institutional framework supports the conservation and sustainable management of forests

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	↙	🟢	🟡	↙	🟡

Data source(s):	DELWP
Measure(s):	Overall assessment results of compliant and non-compliant audits

Why this indicator?

Demonstrating Victoria's commitment to building community awareness, regional assessment, and planning and policy review, is critical for continued improvement of managing and conserving the state's forests. This indicator provides a measure of Victoria's institutional framework elements for forest conservation and sustainable forest management. This framework includes forest audits to ensure that commercial timber harvesting activities are compliant with Victoria's environmental regulatory framework.

Why this assessment in 2023?

Environmental audits of timber harvesting operations in state forests have been undertaken since 2002. The Victorian Conservation Regulator (CR) is now responsible for overseeing the Forest Audit Program as part of its regulatory remit. The CR has established the Acquittal of Audit Recommendations, and Overall Environmental Conformance – Forest Audit Program 2015–16 to 2020–21 to enable a high-level comparison of overall conformance by VicForests in each audit theme across several years.

The audit reports contain 73 recommendations to rectify potential environmental impacts. Of the 73 recommendations, four high-priority recommendations that are the responsibility of VicForests remain incomplete or are ongoing (partially complete). All recommendations that are currently incomplete or ongoing for which DEECA is responsible are related to recommendations for changes to the Code of Practice for Timber Production 2014 to improve regulatory clarity and environmental outcomes. Most non-conformances were found to have no environmental impact, negligible environmental impact or minor environmental impact. The incidence of non-conformances with potential for major environmental impact has fluctuated; however, a general decrease has been observed since 2016–17. These non-conformances are monitored closely by the CR. However, VAGO found a number of weaknesses in the CR's effectiveness in regulating timber harvesting operations.

There is sufficient information on the institutional framework that supports the conservation and sustainable management of forests; this includes an audit of the CR by VAGO.

Summary of State of the Environment 2018 Report assessment

- VicForests has indicated a high level of compliance with lower risk prescriptions for timber production harvesting and coupe closure activities throughout the reporting period.
- Some coupes that were harvested between 2014-15 and 2015-16 were assessed to have major environmental risk. A number of these coupes have been increasing, which must be identified and investigated in the future.

Critical data used for the 2023 assessment

- Institutional framework elements in Victoria for conservation and sustainable forest management (2018 to 2022)
- Audit results of all audit coupes for harvesting and coupe completion operations in eastern Victorian RFA regions

2023 assessment

Institutional frameworks aim to encourage certain activity or behaviours within a sector. The processes, resources and activities provided through institutional frameworks create an environment that influences how effectively and efficiently the aims of the framework are delivered. The level of commitment, and ability of the framework to produce outcomes, can be monitored through the level of support the current conservation and sustainable forest management aims receive.

The Victorian Government is responsible for ensuring that commercial timber harvesting activities are compliant with Victoria's environmental regulatory framework. DELWP was responsible for enforcing timber harvesting compliance until the CR was established in early 2019 as a result of a recommendation from a 2018 review commissioned by the secretary of DELWP following DELWP's unsuccessful prosecution of VicForests for an alleged breach of the *Sustainable Forests (Timber) Act 2004*. The Timber Harvesting Compliance Unit of the CR regulates timber harvesting. They have two main programs relating to compliance issues, the Coupe Inspection Program (CIP) and the Forest Audit Program (FAP). Both programs have a risk-based approach to evaluating industry compliance which is achieved using the characterisation of the coupes in information provided to it by VicForests.[1464] The CR uses both programs to proactively detect noncompliance and identify risks of environmental harm. Based on the findings that arise from these two programs, regulatory actions, guidance notes or provisions of information (if required) are developed.

In 2022, VAGO investigated whether the CR effectively monitors and enforces compliance with timber harvesting regulations.[1465] Despite the improvements achieved by the CR since its establishment in 2019, VAGO found a number of weaknesses in the efficacy of regulating timber harvesting operations by the CR. These are related to a heavy reliance on third party evidence when complaints are received as well as gaps in policies, procedures and the MER framework. DELWP has either accepted or accepted in principle all 10 recommendations made in the VAGO report.

Key activities undertaken to strengthen the institutional framework between 2018 and 2023 include:

- establishment of the Office of the CR
- amending the Code of Practice for Timber Production (2014), with a comprehensive review expected by December 2023
- review of FMPs and RFAs
- assessment of values of IPAs in the Strathbogie Ranges and Mirboo North
- the announcement of the VFP.

Table Fo23 below provides an overview of the institutional framework elements in Victoria for conservation and sustainable forest management in both public and private forests.

[1464] Victorian Auditor-General's Office (VAGO) 2022, 'Regulating Victoria's native forests', Melbourne, Victoria, https://www.audit.vic.gov.au/report/regulating-victorias-native-forests?section=34232--1-audit-context&show-sections=1#34232--1-audit-context Accessed 10 October 2022.

[1465] Ibid.

Table Fo23: Elements of the institutional framework in Victoria for conservation and sustainable forest management between 2018 and 2022.[1466]

Element	Public	Private	Responsible organisation	Key activities during the SoE 2023 reporting period
Administrative arrangements	Yes	Yes	DEECA Local government Parks Victoria VicForests Catchment Management Authorities	Introduction of *Parks Victoria Act 2018* and associated reforms
Public engagement and participation	Yes	Yes	DEECA Local government	RFA - Community Consultation RFA - Scientific Advisory Committee RFA - Reference Group RFA Major Event Review 2019-20 Bushfires – independent panel consultation IPAs: Mirboo North and Strathbogie Ranges – community consultation (Eminent Panel for Community Engagement) Comprehensive review of the Code of Practice for Timber Production (2014) – Community consultation
Periodic forest-related planning	Yes	No	DEECA	Allocation Order Timber Release Plan Forest Coupe Plan Timber Utilisation Plans Review of FMPs
Periodic assessment of forest values	Yes	No	DEECA VicForests	VFMP RFA – Further Assessment of Matters 2019 RFA – Assessment of Ecosystem Services from Forests in Victoria RFA – Major Event Review 2019-20 Bushfires RFA – Threatened Species and Communities Risk Assessments IPAs – VEAC Assessment of Mirboo North and Strathbogie Ranges Detection-based zoning amendments Accountability Framework
Periodic review of forest-related policy	Yes	Yes	DEECA	RFA review VFP Variation of the Code of Practice for Timber Production 2014 Amendments to the Code of Practice for Timber Production (2014) in 2021 and 2022 Comprehensive review of the Code of Practice for Timber Production (2014) by December 2023
Relevant skills development and maintenance	Yes	Yes	Universities Registered Training Organisations DEECA	
Infrastructure	Yes	Part	DEECA PV Local government	Access roads Recreation and fire management infrastructure Victoria's Great Outdoors
Law enforcement	Yes	Yes	DEECA PV Local government	Timber harvesting compliance Wildlife compliance General forest and park compliance

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1466. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Forest Audit Program

The Victorian Government is responsible for ensuring that commercial timber harvesting activities comply with Victoria's environmental regulatory framework. In 2019, the CR was established and has the responsibility to ensure that commercial timber harvesting activities are compliant with Victoria's environmental regulatory framework.

Environmental audits of timber harvesting operations in state forests have been undertaken since 2002. The CR is now responsible for overseeing the FAP as part of its regulatory remit. The purpose of the FAP is to create an environment of continuous improvement for timber harvesting practices and regulation. Audit reports and formal responses are published on the CR's website.

Harvested coupes are assessed by independent auditors and, if non-conformances are detected, the magnitude of the potential environmental impact is recorded using the following categories: no impact, negligible, minor, moderate, major or severe. More information regarding the Forest Audit Program is available on the Victorian Government website.[1467] Since 2017–18, audits have targeted elements of the regulatory framework that have been assessed as having a high risk of causing environmental harm. Where instances of non-conformance with the regulatory framework are detected, their potential environmental impact is assessed using the FAP's environmental impact assessment (EIA) tool. The assessment method is provided in the audit report.[1468]

The CR has established an Acquittal of Audit Recommendations and Overall Environmental Conformance – Forest Audit Program 2015-16 to 2020-21 to enable a high-level comparison of overall conformance by VicForests in each audit theme across multiple years.[1469]

The audit reports contain 73 recommendations to rectify potential environmental impacts. Of the 73 recommendations, four high priority recommendations, which are the responsibility of VicForests, remain incomplete or ongoing (partially complete). All recommendations that are currently incomplete or ongoing for which DEECA is responsible are all related to recommendations for changes to the Code of Practice for Timber Production 2014 to improve regulatory clarity and environmental outcomes. In addition, most non-conformances were found to have no impact, to be negligible or to have minor environmental impact. The incidence of non-conformances with a potential for major environmental impact has fluctuated, however, a general decrease has been observed since 2016–17. These non-conformances are monitored closely by the CR.

Table Fo24 below demonstrates the overall assessment results of conformant and non-conformant audit elements by different environmental impact categories between 2017–18 and 2020–21. Audits for the reporting period 2021–22 have not been included in the below table as these are still being completed and were not available for inclusion within the SoE 2023 Report.

[1467] State Government of Victoria, 'Forest audits', https://www.vic.gov.au/forest-audits Accessed 20 April 2023.

[1468] Jacobs Group (Australia) Pty Limited 2021, 'Audit of timber harvesting operations in Victoria's state forests - Report of the 2020-21 Forest Audit Program', https://www.vic.gov.au/sites/default/files/2022-06/is377900-03%20fap2020-21%20audit%20report-final_0.docx Accessed 20 April 2023.

[1469] State Government of Victoria, 'Acquittal of audit recommendations, and overall environmental conformance - Forest Audit Program 2015/16 - 2020/21', https://www.vic.gov.au/forest-audits Accessed 20 April 2023.

Table Fo24: Audit results for all coupes assessed for harvesting and coupe completion operations in eastern Victorian RFA regions between 2017-18 and 2020-21.[1470]

Audit report year	2017-18	2018-19	2019-20	2020-21
Harvesting year	2016-17	2017-18	2018-19	2019-20
# coupes assessed	30	40	30	30
Mean conformance score for audit (%)	91	84	94	94
Severe	0	0	0	0
Major	4	33	1	5
Moderate	23	32	26	31
Minor	13	63	24	30
Negligible	6	21	3	13
No impact	-	-	-	-
Areas with <90% compliance	Protection of forest soils Road design, maintenance and closure	Protection of forest soils Protection of water flows, water quality and river health Protection of biodiversity values Coupe infrastructure Road design, construction, maintenance and closure	Coupe infrastructure Road design and construction	In coupe road design, construction, maintenance and closure

On 7 November 2019, the Victorian Government announced Victoria's Forestry Plan, which includes a commitment to immediately end harvesting of old growth forest. The CR has established an Old Growth Forest Field Identification Assessment Tool and regulatory guide. The Old Growth Forest Identification Assessment Tool outlines a step-by-step procedure that must be followed to identify old growth forest so that it can be protected. The assessment tool must be consistently applied prior to timber harvesting throughout the state of Victoria.

The Major Event Review of the 2019-20 bushfires found that, if a patch of old growth identified by desktop assessment is smaller than one hectare, the area will be included for timber harvesting.[1471]

Although VicForests advised that their voluntary field survey for all coupes will ensure that these small patches of modelled old growth forest will be protected as part of retention harvesting plans, the field identification procedure cannot cover this. Therefore, the Independent Panel of the Major Event Review report recommended 'that DELWP improves the resolution of the field identification assessment tool for forest patches to better identify remnant patches of old growth forest' (Recommendation 9).[1472]

1470. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.
1471. Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf Accessed 21 November 2022.
1472. Ibid.

Forests

Coupe Inspection Program

CIP is the CR's new approach to proactively assessing industry compliance to prevent environmental harm during timber harvesting. The CR aims to inspect coupes based on the presence of important environmental values and high-risk activities. Information they use to select coupes includes threatened species surveys, results from the FAP and the history of surrounding areas near coupes. The CR issues written requests to modify planning or remedy minor issues when risks are identified. It has the authority to give formal directions or suspension notices under legislation. Among the 53 coupes inspected in 2021-22, two coupes were found to be non-compliant.[1473]

Forest Reports

Members of public can report the detection of threatened species in timber harvesting areas or potential timber harvesting compliance issues.[1474] Once a forest report is submitted, authorised officers undertake an assessment of each report. The CR received 123 forest reports between 2019-20 and 2021-22. Outcomes from the forest reports show that 94 reports (76% of the 123 reports) were not accepted for investigation and eight did not identify a breach or resulted in no further action.[1475] In 2021-22, three letters of advice, one formal written warning and three directions for remediation regarding timber harvesting activities were issued in relation to the conduct of VicForests and their contractors.[1476]

Forest Protection Survey Program

The Forest Protection Survey program, established in 2018, aims to protect animals and plants that are either threatened or of high conservation value where they occur in areas (or coupes) of state forests scheduled for harvesting. This survey work is taking place in state forests in eastern Victoria (Gippsland, the Central Highlands and North-East regions). The aim of the program is to survey at least 80% of coupes planned for harvest each year. VicForests is also required to undertake its own assessment of biodiversity values on coupes prior to harvesting. The Major Event Review report found that threatened species observations from pre-harvest and post-harvest surveys have increased at least four-fold in the three years since the program commenced.[1477] However, this does not necessary mean that current detection, protection or mitigation have improved due to the program. This should result in better knowledge about, and improved decisions on, protection measures for those threatened species that occur in the vicinity of planned timber harvesting.

[1473] Conservation Regulator (CR) 2021, 'Acquittal of audit recommendations and overall environmental conformance - Forest Audit Program 2015-16 to 2020-21'. Melbourne, Victoria.
[1474] State Government of Victoria, 'Submit a forest report', https://www.vic.gov.au/forest-reports Accessed 20 April.
[1475] Conservation Regulator (CR) 2021, 'Acquittal of audit recommendations and overall environmental conformance - Forest Audit Program 2015-16 to 2020-21'. Melbourne, Victoria.
[1476] State Government of Victoria, 'Regulating timber harvesting', https://www.vic.gov.au/year-review-2021-22/regulating-timber-harvesting Accessed 20 April 2023.
[1477] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires', https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf Accessed 21 November 2022.

Forests

Indicator Fo:18 Extent to which the economic framework supports the conservation and sustainable

Fo:18 Extent to which the economic framework supports the conservation and sustainable management of forests

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	?	🔴	🟡	?	🟡

Data source(s):	DELWP
Measure(s):	Description of economic framework in Victoria to quantify and evaluate all relevant aspects for the conservation and sustainable management of forests

Why this indicator?

This indicator describes key economic policy changes and initiatives relevant to the timber industry and biodiversity markets across all land tenures, as well as the conservation of private native forests.

Why this assessment in 2023?

The major change in economic framework during this state of environment reporting period was the announcement of the end of native timber harvesting by 1 January 2024. There is economic support for this substantial change in the industry but, as indicator Fo:01C demonstrates, new plantation establishment has not been reflected in the data. The State Budgets in this state of environment reporting period show forest-related investments. However, asthe budget information relates only to the monetary investment in forest management, it does not indicate the effectiveness of government investment in supporting conservation and sustainable management of forests. More comprehensive information is, therefore, required to assess this indicator, particularly the outcomes arising from the economic framework.

Summary of State of the Environment 2018 Report assessment

- Although there are several economic frameworks to support the conservation and sustainable management of forests, limited datasets at the state-scale make it difficult to assess this indicator and detect trends.

Critical data used for the 2023 assessment

- Summary of high-level investment towards supporting conservation and sustainable management of forests

2023 assessment

The Victorian Government is responsible for forest management across public land and for regulatory functions that extend across both public and private land. Victoria's forest management system is a comprehensive system for delivering sustainable forest management across all land tenures.

Forest management is administered by several state agencies that have complementary roles and responsibilities. The Government establishes its budget and economic framework to resource these agencies so they can run their forest management activities.

This indicator assesses whether the current economic framework supports sustainable forest management. It lists the economic framework elements considered important for supporting conservation and sustainable management of both public and private forests.

Ending native timber harvesting by 1 January 2024

In 2019, the Government announced the phasing out of all public native forest timber harvesting by 2030. To support industry transition, the Government developed the VFP and is undertaking long-term investment in plantations and farmed timber.[1478] The VFP provides more than $200 million to support workers, businesses and communities through their transition away from the native timber industry ahead of commercial timber harvesting ending in 2030.

[1478] Department of Jobs, Skills, Industry and Regions (DJSIR) 2023, 'Victorian forestry plan', https://djsir.vic.gov.au/forestry/forestry-plan Accessed 20 April 2023.

Forests

As a result of ongoing court and litigation processes and increasingly severe bushfires, the Victorian Government decided to bring forward the timeline to 1 January 2024. This decision also brings an additional $200 million in support for forestry workers and their families to successfully transition to plantation timber industry and contributing to fire management.

State Budget initiatives 2018–22

In addition to funding core forest management activities conducted by its agencies, the Victorian Government has committed funding towards additional conservation and forest management initiatives over a five-year period. The following list is not exhaustive, however it does demonstrate high-level investment geared towards supporting conservation and sustainable management of forests:

- In 2018–19 the Government committed:
  - $35.9 million to modernise regional forestry agreements and improve the surveying of forestry land, helping to better protect the environment and give industry certainty
  - $3 million to manage faunal emblems
  - $1.3 million to manage weeds and pests.[1479]
- In 2019–20 the Government committed $6.9 million to conserve Victoria's parks by maintaining park ranger positions, ensuring Victorians can continue to enjoy our state's parks.[1480]
- In 2020–21 the Government committed:
  - $3.6 million for the Victorian Deer Control Strategy, with a further $4.5 million provided in 2021–22
  - $1.9 million over two years (2020–22) for the Yellingbo (Liwik Barring) Landscape Conservation Area.[1481]
- In 2021–22 the Government committed:
  - $52 million to support volunteers, local community organisations and continue the Victorian Landcare Program. This included grants to help protect threatened species, improve local habitats and strengthen our biodiversity
  - $1.3 million towards pest and weed management
  - $1 million to support Trust for Nature
  - $14.3 million for biodiversity protection through community driven action under Biodiversity 2037
  - $3.3 million was committed to wildlife protection and support
  - $12.9 million to deliver Victoria's RFA commitments.[1482]
- In 2022–23 the Government committed $28 million for:
  - eucalyptus seed collection, upgrades to storage facilities and seed viability testing that will support forest contractors and ensure that forests can be reseeded after major fires
  - improved forest protection regulations.[1483]

Information identified for this indicator is insufficient to assess the effectiveness of the current economic framework on a holistic basis. Future analysis should focus on the effectiveness of the Victoria's economic framework in relation to production forests, management of conservation reserves, bushfire management as well as Traditional Owner managed land for sustainable forest management. This should include outcomes of each forest-related investment on a short- and long-term basis.

[1479] State Government of Victoria 2018, 'Victorian Budget 18/19', Melbourne, Victoria, https://s3-ap-southeast-2.amazonaws.com/budgetfiles201819.budget.vic.gov.au/2018-19+State+Budget+-+Budget+Overview.pdf Accessed 20 April 2023.

[1480] Ibid.

[1481] Ibid.

[1482] Ibid.

[1483] Ibid.

Indicator Fo:19 Capacity to conduct and apply research and development aimed at improving forest management, including development of scientific understanding of forest ecosystem characteristics and functions

Fo:19 Capacity to conduct and apply research and development aimed at improving forest management, including development of scientific understanding of forest ecosystem characteristics and functions

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	↗	●	●	→	●
Data source(s):	DELWP					
Measure(s):	Number of FTE employees of government agencies and private companies, and in academia, by research activity					

Why this indicator?

This indicator assesses Victoria's capacity to conduct, and apply, research and development to improve sustainable forest management.

Why this assessment in 2023?

In 2018, DELWP commissioned an independent evaluation that found that both the Integrated Forest Ecosystem Research (IFER) and National Hazards Research Australia (NHRA) agreements, while meeting different needs, contributed significantly to the achievement of long-term outcomes for forest and fire research. The evaluation identified several recommendations to further optimise the use of the agreements. These recommendations have since been adopted and have strengthened the outcomes of the head agreements.

As at 2020–21, the number of Victorian Government staff engaged in forest-related research and development activities was 17 full-time equivalent (FTE) staff, a slight decrease from 18 in 2015–16.

The number of academics funded by the Victorian Government in the area of forest research and development increased by approximately eight FTE staff in total. Increases were for FTE staff involved in the focus areas of silviculture, forest health, fauna ecology, climate change, forest carbon, sustainable forest management, spatial analysis, modelling and remote sensing. By contrast, the number of FTE staff involved in fire behaviour and forest hydrology decreased. For 2016–17, topics related to fire, ecology and hydrology accounted for 80% of overall FTE providers, compared to 2020–21, when spatial analysis, modelling and remote sensing, fire ecology, fauna ecology and sustainable forest management accounted for approximately 70% of overall FTE providers within academia.

Summary of State of the Environment 2018 Report assessment

- Although the overall number of full-time-equivalent (FTE) employees remained unchanged, FTE employees in academia increased by about 4 FTE in fire behaviour and forest hydrology between 2011 and 2017. Conversely, FTEs in government agencies decreased by the same amount in fire and flora ecology. For both years, topics related to fire, ecology and hydrology accounted for 80% of overall FTE employees.
- DELWP says its current budget allocation for research and development is based on identification and prioritisation of research directions. DELWP explained that the expected impact of the research activities on management actions or policy change has been documented.

Critical data used for the 2023 assessment

- New data were unavailable for this indicator

2023 assessment

Victorian forests are highly varied and complex in terms of their ecological and genetic diversity, health, and carbon sequestration. This indicator assesses Victoria's capacity to conduct and apply research and development to improve sustainable forest management.

As at 2020-21, the number of Victorian Government staff engaged in forest related research and development activities was 16.6 full-time-equivalent (FTE) staff, a slight decrease from 17.8 in 2015-16. All research has focused on native forest, with a significant proportion of staff working on fire ecology (5.6 FTE), sustainable forest management (3.44 FTE) and spatial analysis, modelling, and remote sensing (1.5 FTE) in 2020–21. The data on FTE staff engaged in forest related research and development activities in government agencies, shown in Table Fo23, include employees of DEECA, VicForests and ARI.

In addition, there were 34.5 FTE government funded academics working in forest research and development in Victoria. This figure includes academics funded by DEECA through the Integrated Forest and Ecosystem Research (IFER) program at the University of Melbourne, Natural Hazards Research Australia (NHRA), ARI and VicForests. For 2020–21, this included 1.1 FTE working on forest hydrology, 6.0 FTE on fire ecology, 9.6 FTE on spatial analysis, modelling, and remote sensing, 3.5 FTE on sustainable forest management and 4.2 FTE on fauna ecology.

Table Fo25 demonstrates trends in research focuses within Victorian government agencies and academia between 2016–17 and 2020–21. The data on FTEs in government agencies includes DEECA employees (agency research leads for IFER and NHRA projects), VicForests and ARI employees. Academic FTEs include those funded by DEECA through the IFER program, NHRA and ARI, in addition to those funded by VicForests. The number of academics funded by the Victorian Government in forest research and development increased by approximately 8 FTE in total, with increases related to silviculture, forest health, fauna ecology, climate change, forest carbon, sustainable forest management, spatial analysis, modelling, and remote sensing focus areas. Decreases in FTE numbers were observed in fire behaviour and forest hydrology. For 2016-17, topics related to fire, ecology and hydrology accounted for 80% of overall FTE providers, compared to 2020-21 where spatial analysis, modelling, and remote sensing, fire ecology, fauna ecology and sustainable forest management accounted for approximately 70% of overall FTE providers in academia.

Forests

Table Fo25: The number of FTE hours by government employees and academics engaged in forest-related research and development between 2016–17 and 2020–21.[1484]

Research and development activity	Government agencies 1		Academia 2	
	Native forest			
	2016-17	2020-21	2016-17	2020-21
Silvicultural research	0.50	0.24	-	3.12
Tree breeding (not horticultural)	-	-	-	-
Forest hydrology	0.28	0.4	5.2	1.1
Timber use	-	0.7	-	0.3
Fire behaviour	0.85	1.2	12.91	0.8
Forest pathology	-	0.3	-	1
Agroforestry	-	-	-	-
Fauna ecology (including aquatic biota)	6.79	1.6		4.2
Fire ecology	6.84	5.6	6.0	6.0
Forest health and biosecurity	-	0.17	-	1.73
Flora ecology	-	1.1	-	-
Non-timber forest products	-	-	-	-
Climate change	-	0.03	-	1.4
Statistical analysis	-	0.25	-	0.6
Forest industries	-	-	-	-
Sustainable forest management	1.51	3.44	0.90	3.5
Spatial analysis, modelling, and remote sensing	-	1.52	-	9.6
Forest carbon	-	0.05	-	1.1
Resource analysis	-	-	-	-
Other (plantations and health)	1.02	-	2.8	-
Total number of research FTEs	17.79	16.6	26.31	34.50

[1] *The data on FTEs in government agencies includes DEECA employees (agency research leads for IFER and NHRA projects), VicForests and ARI employees.*

[2] *Academic FTEs include those funded by DEECA through the IFER and NHRA programs, ARI, plus those funded by VicForests. Agency, ARI, and academic FTE data taken from internal DEECA and VicForests spreadsheets and relevant project documentation.*

Note: These figures only include the relative time researchers, technicians and other staff were directly involved with research and development activities. They do not include the relative time of overhead staff (e.g. administrative and general service employees or personnel officers).

1484. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

The two main research head agreements (IFER and NHRA) are the major providers involved in forestry research and development in Victoria. In 2018, DELWP commissioned an independent evaluation which found that both the IFER and NHRA agreements, while meeting different needs, contributed significantly to the achievement of long-term outcomes for forest and fire research. The evaluation identified several recommendations to further optimise the use of the agreements which have since been adopted, strengthening the outcomes of the head agreements.

University of Melbourne - Integrated Forest Ecosystem Research Agreement

The IFER agreement is a collaborative research initiative between the School of Ecosystem and Forest Sciences at the University of Melbourne and DEECA. The IFER agreement is designed to meet emerging departmental needs in critical policy and operational areas within Victoria's public forests such as bushfire, forests, and climate. The IFER program has led to significant improvements in the way DEECA delivers its land and bushfire management priorities. For example, research undertaken through the IFER agreement has enabled DEECA to improve planned burning regimes to benefit biodiversity and minimise carbon loss, improve bushfire behaviour predictions and has led to the development of risk assessment tools that enable better prediction of post-fire water hazards, like contamination, debris flows and flooding.

Through the IFER core program, teams investigate forests in Victoria under four main landscape-level themes: Landscape Decision Support System, Forest Biodiversity and Community Dynamics, Forest Carbon and Water, and Forest Social Values.

NHRA (successor of the Bushfire CRC and the Bushfire and Natural Hazards CRC)

Building upon the foundations of both the Bushfire Cooperative Research Centre (CRC) and the Bushfire and Natural Hazards CRC, NHRA was funded for 10 years by the Australian Government on 1 July 2021 as a collaborative research organisation to address the major challenges arising from natural hazards, including bushfires, floods, cyclones, heatwaves, storms, and other hazards. NHRA works in the broad emergency management and disaster resilience sector, with partners in all states and territories, federal, state, and local governments, key industry bodies, the private and not-for-profit sectors, research, and other organisations with a stake in protecting Australian communities.

The interdisciplinary research coordinated by NHRA supports the development of cohesive, evidence-based policies, strategies, programs, and tools to build a more disaster-resilient Australia.

NHRA is 'end-user driven', meaning its partners, including various emergency service agencies, departments and non-government organisations around the country, have a significant say in the development and use of the research program – facilitated through an annual subscription program.

In addition to the annual subscription program, DELWP and NHRA established the Forest and Fire Risk Management Transfer Payment Funding Agreement in June 2021 (and previously the Emergency Risk Management and Bushfire Risk Management Research Agreements) to support DEECA's specific needs in bushfire risk management research. This Agreement and its predecessors have delivered over ten years of investment in collaborative research on bushfire science that has re-framed and improved our understanding of bushfires and how we manage risk to the environment and our communities. It has also enabled DEECA to meet policy and operational evidence needs to deliver across a wide range of areas, including ecological monitoring, fire behaviour modelling, smoke modelling, and climatology.

Socio-economic benefits

Forests provide significant benefits to the social, cultural and economic fabric of Victoria. However, these benefits can be difficult to quantify, and translating ecosystem services into economic values is challenging. Indicators under this theme describe the current state of ecosystem services that are derived from forests in Victoria and provide Government's investment and expenditure in forest management.

Forests

Indicator Fo:20 Investment and expenditure in forest management

Fo:20 Investment and expenditure in forest management						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🟡	↙	🟢	🟡	→	🟢
Data source(s):	DELWP, VicForests					
Measure(s):	Expenditure on forest management					

Why this indicator?

This indicator measures trends in forest management expenditure, reported as Victorian Government expenditure on forest management related activities within state forests, parks and reserves, as well as VicForests expenditure on forest management.

Why this assessment in 2023?

Reported expenditure on conservation and recreation more than doubled between 2017–18 and 2021–22. Forest and fire management had a spike in expenditure due to support for the response to the severe bushfire events in 2019–20. As a result of a changed timeframe for ceasing native timber harvesting, forestry contract workers will transition to contributing to bushfire risk reduction as a result of growing bushfire risk. This is likely to lead to an increase in forest and fire management after the transition is complete.

VicForests' revenue has been stable since 2012–13 after a fluctuation of between $100 million and $140 million. Total expenditure was within a similar range until 2018–19, which resulted in a net result after tax of between -$5 million and $5 million. However, the net result after tax shifted dramatically between 2019–20 and 2021–22: recording a net loss of $54 million in 2021–22 from continuing operations. This is the largest net loss from continuing operations in 15 years.

Summary of State of the Environment 2018 Report assessment

- Expenditure for forest fire management was reduced to $269.9 million in 2016–17. Prior to this, it fluctuated, including up to $396.5 million in 2015–16.
- Reported expenditure on conservation and recreation increased significantly between 2014-15 and 2016-17 to $369.8 million. This may reflect increased Victorian Government focus on conservation and recreational values in state forests and parks and reserves. More details on their expenditure would improve indicator assessment.

Critical data used for the 2023 assessment

- VicForests Annual Reports
- Victorian Government's expenditure on forest management

2023 assessment

Effective sustainable forest management relies on adequate investment and expenditure. Investments and expenditures are necessary to ensure that infrastructure, facilities, forest health and conservation values are maintained.

This indicator measures trends in forest management expenditure, reported as Victorian Government expenditure on forest management related activities, which includes state forests and parks and reserves, as well as VicForests expenditure on forest management.

Together, with Parks Victoria and VicForests, DEECA is responsible for managing Victoria's parks and reserves, and state forests. VicForests on the other hand is a separate, government-owned business responsible for the harvest, commercial sale and regrowing of wood from Victoria's state forests.

Table Fo26 shows the expenditure for managing Victoria's forests, parks and public land between 2017-18 and 2021-22. Expenditure on conservation and recreation more than doubled over the five-year period from around $155 million to $371 million. There was a spike of expenditure on forest fire management in 2019-20, reaching around $650 million, which then fell to $348 million in 2021-22. The sharp increase was due to significant investment on supporting the response to the intense 2019-20 bushfire season.

As a result of the announcement of the revised timeline for the VFP from 2030 to 1 January 2024, forest contractor workers will be supported to transition to contributing bushfire risk reduction.[1485] As bushfire risk is growing as a result of changing fire regime, the transition will provide better support to respond to future severe bushfires. This is likely to lead to an increase of expenditure on forest and fire management once the transition is complete.

Table Fo26: Victorian Government expenditure on forest management from 2017-18 to 2021-22.[1486]

Expenditure category	Expenditure ($ millions)				
	2017-18	2018-19	2019-20	2020-21	2021-22
Forest and fire management	346.1	484.3	649.6	366.0	348.0
Conservation and recreation	155.3	167.8	221.9	281.4	371.5
Total	501.4	652.1	871.6	647.4	719.5

VicForests' revenue has been stable since 2012-13 after a fluctuation between $100 million and $140 million (Figure Fo28). Total expenditure was within a similar range until 2018-19, which resulted in a net result after tax of between -$5 million and $5 million. However, the net result after tax shifted dramatically between 2019-20 and 2021-22, making a net loss of $54 million in 2021-22 for continuing operations. This is the largest net loss from continuing operations within 15 years. VicForests explained that this is due to a number of factors for major expenditure:

- Further pressure on revenue from the sale of timber has been realised through compensation payments paid to customers where VicForests has been unable to supply the minimum allowable under the respective timber supply agreements ($7.5 million).
- At the gross margin level, harvest and haulage expenditure has been adversely affected by stand down payments to external contractors where coupe availability has prevented harvest activity ($6.2 million).
- Increased litigation by environmentalist groups undertaken during the year has placed a significant burden on indirect expenses ($10.4 million).[1487]

There are many factors that are likely to negatively impact on their balance sheet in the future, including more frequent and intensive bushfires, climate change and greater regulations for biodiversity protections during native timber harvesting. This indicates that VicForests' current financial balance may deteriorate further until Victoria phases out of native timber harvesting by 2024.

[1485] Premier of Victoria 2023, 'Delivering certainty for timber workers', Melbourne, Victoria, https://www.premier.vic.gov.au/delivering-certainty-timber-workers Accessed 25 May 2023.
[1486] Department of Energy, Environment and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.
[1487] VicForests 2022, 'Annual report 2021-22', Melbourne, Victoria.

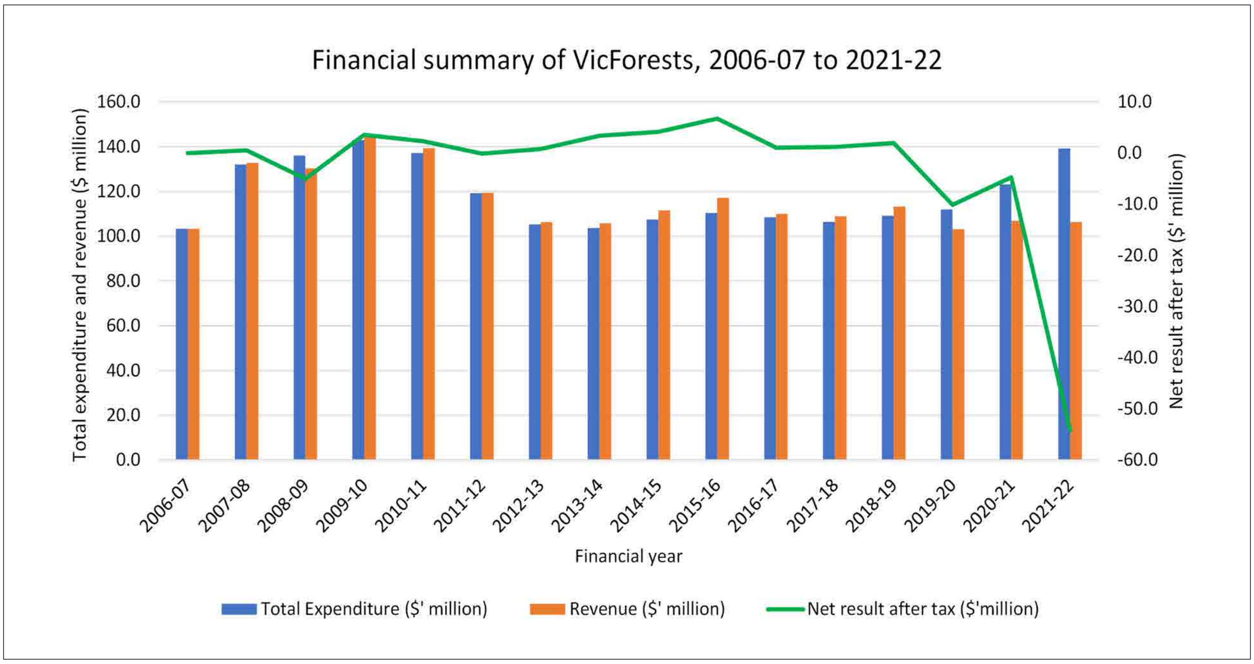


Figure Fo28: Financial summary of VicForests between 2006-07 and 2021-22.[1488]

[1488] VicForests, 'Annual reports', https://www.vicforests.com.au/publications-media/corporate-documents/annual-reports Accessed 4 May 2023.

Indicator Fo:21 Value ($) of forest-derived ecosystem services

Fo:21 Value ($) of forest-derived ecosystem services

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	?	●	●	?	●

Data source(s):	DELWP
Measure(s):	Value ($) of forest-derived ecosystem services

Why this indicator?

Forest ecosystems provide valuable services to the Victorian community. These include maintaining water and soil quality, protecting biodiversity and mitigating global warming. This indicator evaluates these services in monetary terms to better reflect the contribution of Victoria's public forests to the Victorian economy.

Why this assessment in 2023?

Physical and monetary values of forest ecosystem services were provided. Victoria's forest ecosystem services range in total value between an estimated $7 billion and $12 billion, with soil retention affording the largest monetary value among all ecosystem services. This quantification is based on many assumptions, and sometimes estimation was based on alternative options.

Quantifying all forest assets and values in monetary terms poses a challenge. Despite a significant effort to cover most forest ecosystem services, there are still data limitations. Thus, a trend analysis for most ecosystem services was not possible.

Summary of State of the Environment 2018 Report assessment

- There is no state-scale approach that quantifies the value of forest-derived ecosystem services in Victoria.
- Existing regional-scale approaches could be expanded to work on a state-scale.

Critical data used for the 2023 assessment

- Multiple international, national and sub-national data sources to estimate physical and monetary values of various forest assets

2023 assessment

Forest ecosystems provide a suite of ecosystem services, including climate regulation, carbon sequestration, water supply and filtration and habitat. The management and condition of forests determines the level and extent of these services and, in turn, the benefits to the economy and community.

Environmental–economic accounting provides a framework for valuing the economic benefit of ecosystem services to the economy and society. The contribution forests make to the economy is partially captured in the System of National Accounts (SNA), which accounts for goods and services from forests (e.g. timber and tourism) when they are produced and consumed in the economy. The System of Environmental Economic Accounts extends upon the SNA by including environmental assets in forests and the natural inputs and ecosystem services they produce.

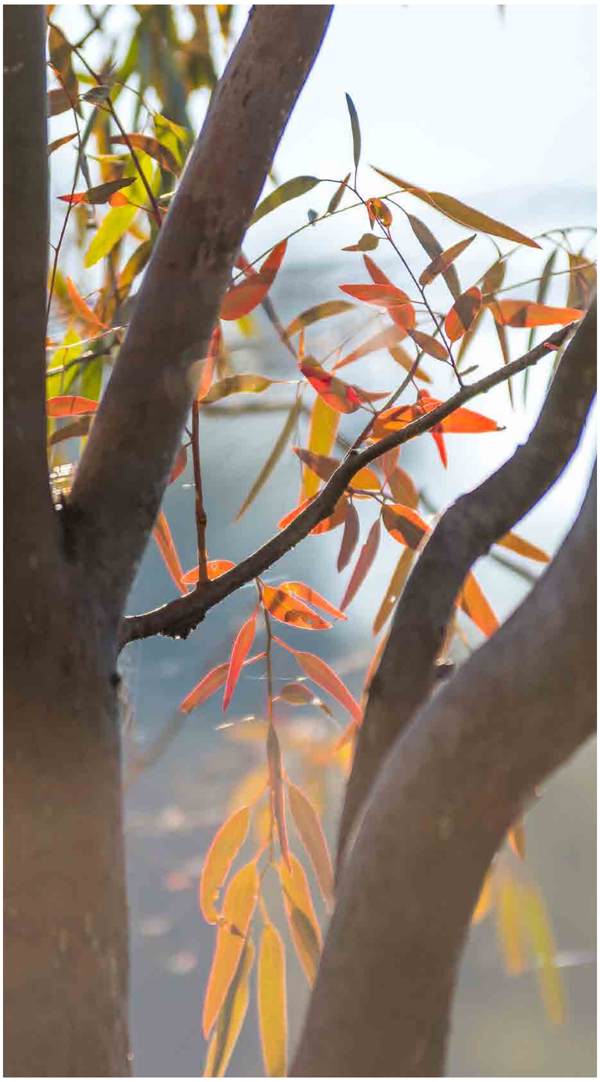
Within both the SoE 2018 Report and in this SoE 2023 Report, the data and narratives for this indicator were developed by DELWP. This update provides a summary of the work that DELWP has undertaken relevant to this indicator since the 2018 report, namely the Ecosystem Services from Forests in Victoria: Assessment of Regional Forest Agreement Regions.[1489] It is important to note that there has also been work undertaken by DELWP and others which may be relevant to this indicator, including (but not limited to) Ecosystem Services from Forests in Victoria: Impact of the 2019-20 Bushfires.

1489. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Ecosystem services from forests in Victoria: Assessment of regional forest agreement regions', Melbourne, Victoria.

Experimental Ecosystem Accounts for the Central Highlands of Victoria, and Experimental Ecosystem Accounts for an Icon Site in the Murray-Darling Basin.[1490, 1491, 1492]

Table Fo27 summarises the physical and monetary ecosystem service values for forests in RFA regions in Victoria. RFA regions cover over six million hectares of forests, or approximately 80% of Victoria's forests. Physical and monetary estimates are for 2018 unless otherwise stated.

For some ecosystem services the actual physical flow could not be estimated, and proxy indicators are reported instead. An example of this is provision of fodder, where area of agricultural licenses is reported instead of the actual quantity of fodder. Not all ecosystem services could be measured in physical or monetary terms, but this does not imply a lack of value.



Hattah Kulkyne Mallee.
Credit: Annette Ruzicka.
© Parks Victoria.

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1503. Department of Environment, Land, Water and Planning (DELWP) 2018, 'Northern Victoria firewood and home heating project: Final recommendations', Melbourne, Victoria.
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1507. Water Technology 2017, ' Wangaratta urban waterways flood investigation: Study report', Notting Hill, Victoria, https://www.wangaratta.vic.gov.au/files/assets/public/files/policies-amp-documents/your-council/strategies-and-plans/wangaratta-urban-flood-study.pdf Accessed 20 April 2023.
1508. Department of Water 2009 'Water notes for river management: Advisory notes for land managers on river and wetland restoration', WN38, Perth, Western Australia.
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1510. Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) 2016, 'Australian honey bee industry: 2014-15 survey results', Canberra, Australian Capital Territory.
1511. Quantum Market Research 2019, 'Understanding state forest visitation and tourism', report prepared for the Department of Environment, Land, Water and Planning.
1512. Deloitte 2014, 'The economic contribution of tourist visitation to Victorian parks: Valuing the tourism services provided by Victorian parks', report prepared for Parks Victoria (PV), pp. 103-111.

Table Fo27. Ecosystem services from forests in the Central Highlands, East Gippsland, Gippsland, North East, and West RFA regions in Victoria.[1493]

Ecosystem services [a]	Physical value		Monetary value		Confidence [b]
	Estimate	Data source	Estimate ($m)	Data source	
Provisioning services					
Water	6,432 GL	Biosym modelling	774-1,270	Productivity Commission (2011)[1494] Western et al. (2017)[1495] DTF (2009)[1496]	🟧
Native timber	1,154,465 m^3	VicForests (2019)[1497]	28	VicForests (2019)[1498]	🟩
Plantation timber [c]	7,839,128 m^3	ABARES (2019)[1499]	54	VicForests (2019)[1500] ABARES (2019)[1501]	🟧
Firewood [d]	45,000 m^3	DELWP (n.d.)[1502]	3-7	DELWP (2018)[1503]	🟥
Honey	1,000-1,500 tonnes	ABARES (2016)[1504] DELWP (2015)[1505]	3.0-4.5	ABARES (2016)[1506]	🟥
Fodder (agricultural licenses) [e]	494,391 ha	DEECA dataset	NA [f]	NA	🟩
Regulating services					
Water flow regulation (no. of localities with reduced flood peaks)[g]	646	Biosym modelling	97	Water Technology (2017)[1507]	🟥
Soil retention	382Mt	Biosym modelling	3,054-8,021	Department of Water (2009)[1508]	🟥
Carbon sequestration [c]	41 MtC	DEECA dataset [h]	3,006	World Bank's Carbon Pricing Dashboard[1509]	🟧
Carbon storage [c]	1,061 MtC	DEECA dataset	NA	NA	🟩
Pollination (no. of apiary sites)[e]	2,475	DEECA dataset	0.8-1.0	ABARES (2016)[1510]	🟥
Cultural services					
Recreation[c]	34,000,000 visits	Quantum (2019)[1511]	905	Deloitte (2014)[1512]	🟧

Note: RFA regions cover over 6 million hectares of forests (80% of Victoria's forests).

Note: An indication of confidence in the quantification or valuation of ecosystem services is provided, with green representing higher confidence in the assessment of quantity or value, orange representing medium confidence and red representing lower confidence.

[a] *Annual flow in 2018 unless otherwise stated.*

[b] *RAG confidence rating assigned where red = low confidence, amber = medium confidence, and green = high confidence in the estimated values.*

[c] *Plantation timber data are for 2017-18, carbon data are for 2017, tourism data are aggregated from 2016-17 data (parks) and 2019 data (state forests).*

[d] *Firewood collected by households from state forests.*

[e] *Indicator reported rather than actual physical quantity of ecosystem service.*

[f] *NA indicates data not available at the RFA region level, italics indicates data were derived from spatial or biophysical modelling.*

[g] *Total is less than the sum of RFA regions, as some localities receive water flow regulation services from multiple RFA regions.*

[h] *VFMP dataset.*

Ecosystem services methodology and caveats

Water provision

Quantification

Quantifying the water provision ecosystem service requires identifying the volume of water yield from forest ecosystems that flows into water supply systems, including Melbourne's water supply system and regulated and unregulated systems across the state. Water yield is modelled using BioSim, which is the biophysical modelling toolbox of EnSym designed to simulate all major hydrological components of the water cycle.

Forest extent and condition is held constant across the period modelled (using 2018 forest extent) and all forests are assumed to be mature. Data on change in forest condition over time is not available, and EnSym by default is unable to model temporal changes in land cover during a model run. However, given ecosystem services are primarily being assessed at the scale of RFA regions, the lack of dynamic land-cover modelling and forest condition change is unlikely to have a meaningful impact on relative findings.

This approach provides an estimate of the yield generated from only the forested parts of catchments based on a number of modelling assumptions. Given this, the yield volume reported in Table Fo22 is not expected to match observed streamflow records and may not be consistent with other measures of Victoria's water resources that are reported in other sections of the SoE 2023 Report or other independent publications. It should be noted that runoff would be generated from these areas in the absence of forest, although the volume would differ from that reported in Table Fo1.

Table Fo22 provides an estimate based on 2018 conditions. Catchment yield is variable over time, primarily influenced by rainfall conditions.

Valuation

A replacement cost approach is used to value water provision to Melbourne's system, and two options are applied as an upper and lower bound. The lower bound estimate is based on the cost of purchasing and transferring water to Melbourne from northern Victoria via a pipeline. The upper bound estimate is based on the cost of supplying water to Melbourne via desalination.

For water provision to other systems, a market price approach is used based on the median price per megalitre of trade in allocated water in each declared system (northern Victoria, Thompson / Macalister and Werribee). For water yield to regulated systems that are not declared (where allocation trade does not occur), and to unregulated systems with sustainable diversion limits, median price per megalitre of trade in temporary take and use licenses is used.

This approach provides a relative indication of the value of the water derived from the forested RFA regions compared to other valued water sources. The valuation does not imply that the full volume of water derived from the RFA regions is available for consumption, nor does it represent the actual cost or economic value to water users supplied from these regions. While used to inform this estimate of replacement cost, the pipeline option is not currently actively used to supply water to Melbourne.

Biomass for timber

Quantification

The ecosystem service of provision of biomass for timber is quantified as the volume of timber harvested from native and plantation forests across RFA regions.

Valuation

The biomass provided by forest ecosystems has a value that is different to timber, as the market value of timber also includes inputs such as harvesting and haulage. Isolating the value of biomass reveals the contribution of the ecosystem. Provision of biomass from native forests can be valued using 'stumpage' revenue. This is a market price valuation technique, as stumpage revenue is the market value of timber less harvesting and haulage costs.

Biomass for firewood

Quantification

The ecosystem service of provision of biomass for firewood is quantified as the volume of firewood collected or harvested from forests across RFA regions. The quantity of firewood collected for domestic use from forests on private land is unknown, though may be significant.

In Victoria, there are restrictions on the volume, location and type of wood that can be collected. Firewood is illegally removed from public land each year, with DEECA and PV undertaking compliance activity. In an ecosystem accounting framework, illegal take could conceptually be included as an ecosystem service provided by forests, as it represents a flow from the ecosystem to people. However, the unsustainable removal of firewood results in degradation of the ecosystem asset (the forest).

Some of the timber harvested by VicForests from state forests is sold and used for firewood, and the quantity and value of this is captured in the previous assessment of timber provision.

Valuation

Provision of biomass for firewood can be valued using market prices. Market prices for firewood can vary widely depending on the type of wood and the location, so a range of prices was used for valuation. Using regional market prices is appropriate for this analysis, as the main user of this ecosystem service is regional households who collect domestic firewood.

Inputs to the provision of biomass for firewood from public land should be subtracted from the market price to isolate the value contributed by the forest ecosystem. Domestic firewood collection is subsidised by the Victorian Government which funds planning and administration of firewood collection areas.

Honey

Quantification

Forests provide habitat that supports bee populations. Forest ecosystem extent provides a broad indicator of provision of habitat for bees. The maintenance of forest ecosystem extent and condition is crucial to supporting bee populations, without which the ecosystem service of honey provision would decline.

Honey production is highly dependent on human inputs such as capital and labour to deliver benefits to people. Although small quantities of wild honey would be obtained directly from forest ecosystems, most honey is produced in artificial beehives by industry or households.

Apiary sites on public land are quantified using the Apiary rights and bee farm and range licenses dataset. Although all apiary sites in this dataset are on public land, for a small number of these sites the nearest forest is on private land. This indicates that apiary sites on public land may be accessing floral resources on private land, and vice versa. Data on the number and location of hives on private land is not available.

Apiary sites are not always licensed, and licensed sites may not always be occupied by hives. Occupation is dependent on nearby floral resources, which are seasonal and variable. Although occupation is sporadic, apiarists tend to retain sites to ensure access. A hive of bees may be moved several times a year.

Honey provision is quantified based on surveys conducted by ABARES on honey production and hive registrations in Victoria, as well as a register of licensed apiary sites on public land across Victoria.

The ABARES study suggests that, at a minimum, 50% of Victorian honey is derived from forests (state forests and parks). However, the proportion is likely higher because 'other public land' and 'other private land' would include areas of forest. For this analysis, an upper bound of 70% is used. This assumes that all 'other public land' and half of 'other private land' is forest.

Given the assumptions made around the use of apiary sites in RFA regions, confidence in the precision of this estimate is low, and it should be considered an indicative estimate only. For the same reason, the quantity of honey attributable to each RFA region cannot be estimated with confidence.

Valuation

The ecosystem service of honey provision is valued using market information reported in the ABARES survey as the difference between the average cash receipts and costs per kilogram of honey.

Fodder

Quantification

Ideally, this service would be measured as the quantity of fodder consumed by grazing livestock. That is, the quantity of plant biomass provided by forest ecosystems from grazing. However, these data are not available and cannot be reliably estimated for Victorian forests.

In the absence of information on the quantity of fodder, opportunities for agricultural use of forests on public land has been mapped using spatial data on licenses for private use of public land. This provides an indication of areas of forest that may provide fodder for grazing livestock.

It should be noted that the number of licenses and area licensed is an indicator of opportunity for use of public forests for agricultural production. It is does not show whether forests are actually being used for grazing or other agricultural purposes.

Water flow regulation

Quantification

Forests in Victorian RFA regions regulate the flow of water which helps to mitigate the impact of flood events. The combination of a locality being in the 1-in-100-year flood zone and having RFA forest in its catchment is used as an indicator of receipt of water flow regulation services.

Spatial analysis was used to identify the Victorian localities that have residential, commercial or industrial areas within the 1-in-100-year flood zone. 646 localities were identified that have RFA forest in their upstream catchment, even if the locality itself is not in the RFA region.

It should be noted that this assessment provides a conservative indication of areas benefiting from water flow regulation services, as it only considers localities with urban, commercial or industrial land. Agricultural areas would also benefit significantly from water flow regulation services provided by forests.

This assessment identifies localities which have a flow attenuation service provided by upstream RFA forested regions but does not attempt to quantify the degree of potential attenuation at any given location. It does not provide a measure of flood risk for any locality.

Valuation

The contribution of water flow regulation to flood mitigation benefits can be valued based on the damage costs that would be incurred in the absence of forests, or the cost of mitigating floods through artificial means such as levees. Damage costs are very location specific and depend on the infrastructure, industries and population that would be impacted by flooding. Damage costs in areas with low population density and fewer industries and infrastructure are typically lower than in densely populated urban areas or areas of significant industrial activity and agricultural production.

A case study of Wangaratta has been undertaken to estimate the avoided flood damage costs due to flow attenuation by forests in the catchment by comparing to a modelled scenario assuming no forests upstream with all forest cover replaced with pasture. The occurrence of flooding in each case is compared and the additional impact is valued using available damage costs.

This case study is then extrapolated out to localities across Victoria to provide an indicative estimate of the broader value of water flow regulation services provided by forests in RFA regions. The Wangaratta case study data provides a linear relationship between the damage cost per hectare of flood prone land and the proportion of the catchment that is forested, which was then applied to all other localities that benefit from flow attenuation services. It should be noted that the statewide estimate is based on top-down extrapolation rather than bottom-up hydrological modelling. Therefore, it should be considered an initial, indicative estimate only. However, it is likely a conservative estimate as it as it only accounts for the tangible costs of damage to property and infrastructure. It does not account for disruption and productivity losses or intangible costs such as deaths, injuries and impacts on health and wellbeing.

Key limitations of this extrapolation are that it assumes a linear increase/decrease in damage costs per hectare of land within the 1 in 100-year flood zone relative to the proportion of the catchment that is forest, and that damage costs in other localities are the same as Wangaratta on a per hectare basis. Biophysical limitations include extrapolating the number and magnitude of flood events from Wangaratta to the rest of the state, however this will be partly mitigated by using the 1 in 100-year flood extents particular to each locality. This assessment also assumes flood waters impacting on a location are always derived from its upstream contributing area; this isn't always the case, particularly in riverine flood events where water can back up or flow into adjacent waterways. The estimated value of this service across Victoria is reported as an average annual dollar value, rather than reflecting the conditions of any particular year.

Soil retention

Quantification

Forests in RFA regions provide soil retention services as vegetation cover helps prevent erosion. A counterfactual scenario, replacing all forest cover with bare earth, is constructed to assess the reduction in soil erosion that can be attributed to forests. This scenario is modelled from 2008 to 2018 using BioSim, alongside the same current forest extent scenario that is used to assess the ecosystem service of water provision and water flow regulation.

The amount of prevented soil erosion to major waterways by forests in RFA regions (compared to the bare earth counterfactual scenario) is reported for 2018 in the table.

Valuation

The ecosystem service of soil retention can be valued based on the avoided cost of repairing damages incurred due to soil erosion under the bare earth counterfactual scenario, such as the cost of dredging waterways to remove sediment. This is among a number of approaches for directly valuing soil retention services identified in a recent discussion paper for the SEEA revision process. This approach requires clearly identifying users or beneficiaries of the ecosystem service, and reasonable actions that could be used to repair damage caused by the loss of soil retention services.

The ecosystem service is valued by applying the cost of sediment removal from inland waterways to the quantity of soil erosion to major waterways across RFA regions. A lower bound estimate applies the cost estimate of soil erosion to regulated water systems (systems that have water storages or weirs). An upper bound value is also estimated that includes the cost of removing sediment from unregulated waterways.

Given the difficultly in estimating the level of demand for this ecosystem service, and the lack of location specific replacement or damage cost information, the value of soil retention services should be interpreted as an indicative estimate only. However, both the quantity of avoided soil erosion to major waterways and indicative estimates of the value of the ecosystem service illustrate that soil retention is a significant ecosystem service provided by forests across RFA regions.

Carbon sequestration and storage

Quantification

Biomass data have been used to calculate the stock of above ground carbon in forests across Victoria. This includes living and dead above ground biomass, but not below-ground biomass (root systems) or soil carbon. Biomass data were supplied from the Victorian Forest Monitoring Program (VFMP) and was created by integrating Landsat satellite timeseries with Victoria's forest monitoring and forecasting framework. A conversion factor of 0.47 is used to convert biomass to carbon.

The account shows additions to carbon stock in each RFA region due to carbon sequestration as well as reductions to stock due to bushfire, harvesting and other factors.

To isolate annual gross reductions in carbon stock and attribute losses to bushfire or timber harvesting annual carbon stocks were subtracted from the proceeding year's carbon stock to produce a dataset of annual carbon change. Timber harvesting and fire history datasets for each corresponding year were then used to define carbon losses as either bushfire, harvesting or other. 'Other' includes reductions in carbon stock due to factors such as the natural dynamics of the forest, natural disturbances such as dieback and storms, and climatic factors such as drought. While the quantity of reductions in stock due to other factors is significant, reductions are reasonably evenly distributed across the landscape, while reductions due to fire or harvesting occur in concentrated areas.

Valuation

The ecosystem service of carbon sequestration can be valued by applying a dollar value to each tonne of CO_{2e}. One tonne of carbon is equal to 3.664 tonnes of CO2-e

In the absence of a clear carbon price in Australia, the central value has been derived from a median of existing international carbon market values, which were obtained from the World Bank Carbon Pricing Dashboard data. Upper and lower bound values can be used for sensitivity testing. The upper bound value is equivalent to the 2018 social cost of carbon estimate derived by the US Environment Protection Agency.

The upper bound value represents a different method of valuing the ecosystem service of carbon sequestration, based on a welfare value. This differs from exchange values which are used to value other ecosystem services in this study.

Pollination

Quantification

Forests provide habitat that supports bees and other pollinators. Forest ecosystem extent provides a broad indicator of provision of habitat for pollinators, including bees. The maintenance of forest ecosystem extent and condition is crucial to supporting pollinators and pollination services. Apiary sites on public land are quantified using the Apiary rights and bee farm and range licenses dataset.

Although all apiary sites in this dataset are on public land, for a small number of these sites the nearest forest is on private land. This indicates that apiary sites on public land may be accessing floral resources on private land, and vice versa. Data on the number and location of hives on private land is not available.

Apiary sites are not always licensed, and licensed sites may not always be occupied by hives. Occupation is dependent on nearby floral resources, which are seasonal and variable. Although occupation is sporadic, apiarists tend to retain sites to ensure access. A hive of bees may be moved several times a year.

Valuation

The contribution of forests to commercial pollination services can be valued using market information reported by ABARES on payments to beekeepers for commercial pollination services and average annual cash costs per beekeeping business. Attributing a portion of these costs to pollination services, in line with the proportion of average cash receipts that are for pollination services (13%), and applying this to the number of commercial beekeeping businesses in Victoria (220) , the reliance of beekeeping businesses on forested areas (50%-70%) and the proportion of apiary sites in RFA regions (55%), the value contributed to commercial pollination services by state forests in RFA regions can be estimated. The forested area estimates of 50-70% have been used as a lower and upper bound for the valuation of the pollination service.

Given the extrapolation of data and assumptions made around the use of apiary sites in RFA regions, confidence in the precision of this estimate is low, and it should be considered an indicative estimate only. However, this represents a lower bound estimate of the value of pollination services, as it is based on the market value of commercial pollination services, rather than the benefit pollination (both commercial and wild) provides to producers and consumers of agricultural products.

Recreation

Quantification

The number of visits to forests can be used as a measure of the ecosystem service. While data on visits to forest ecosystems is not specifically available, data are available on visits to parks and state forests, which can be extrapolated to estimate the number of visits to public forests in RFA regions.

The number of visits to parks is significantly higher than to state forests. This is likely due to high visitation to iconic parks in close proximity to Melbourne such as the Dandenong Ranges National Park, and international tourism to the Port Campbell National Park on the Great Ocean Road. It should be noted that visitation estimates for parks and state forests have been derived from different studies and may not be directly comparable.

The number of visits to forest on private land is unknown but expected to be minimal relative to parks and state forests, as access to forest on private land is generally restricted and there are limited visitation opportunities. However, there would be some visitation associated with private properties such as eco-lodges and camps.

Valuation

Opportunities for recreation can be valued using an indirect market price approach, based on observed purchases of goods and services that are directly related to visiting and recreating in forests. The benefit people obtain from visiting a forest can be estimated by understanding the demand for associated goods and services.

This analysis draws on two studies undertaken to estimate the tourism expenditure associated with visitation of parks and state forests. It should be noted that these studies were undertaken at different times and using slightly different methodologies. These estimates are for tourism associated with parks and state forests across the whole of Victoria. It should be noted that this top-down disaggregation based on area does not account for differences in tourism to different parts of the state.

This estimate may overstate the direct contribution of the ecosystem, as people gain value from infrastructure that enhances tourism and recreational experiences such as signage, picnic and camping facilities and walking and mountain biking trails. The ecosystem and built assets function together to deliver value in the economy and community.

Dandenong Ranges National Park.
Credit: Greg Elms Photography.
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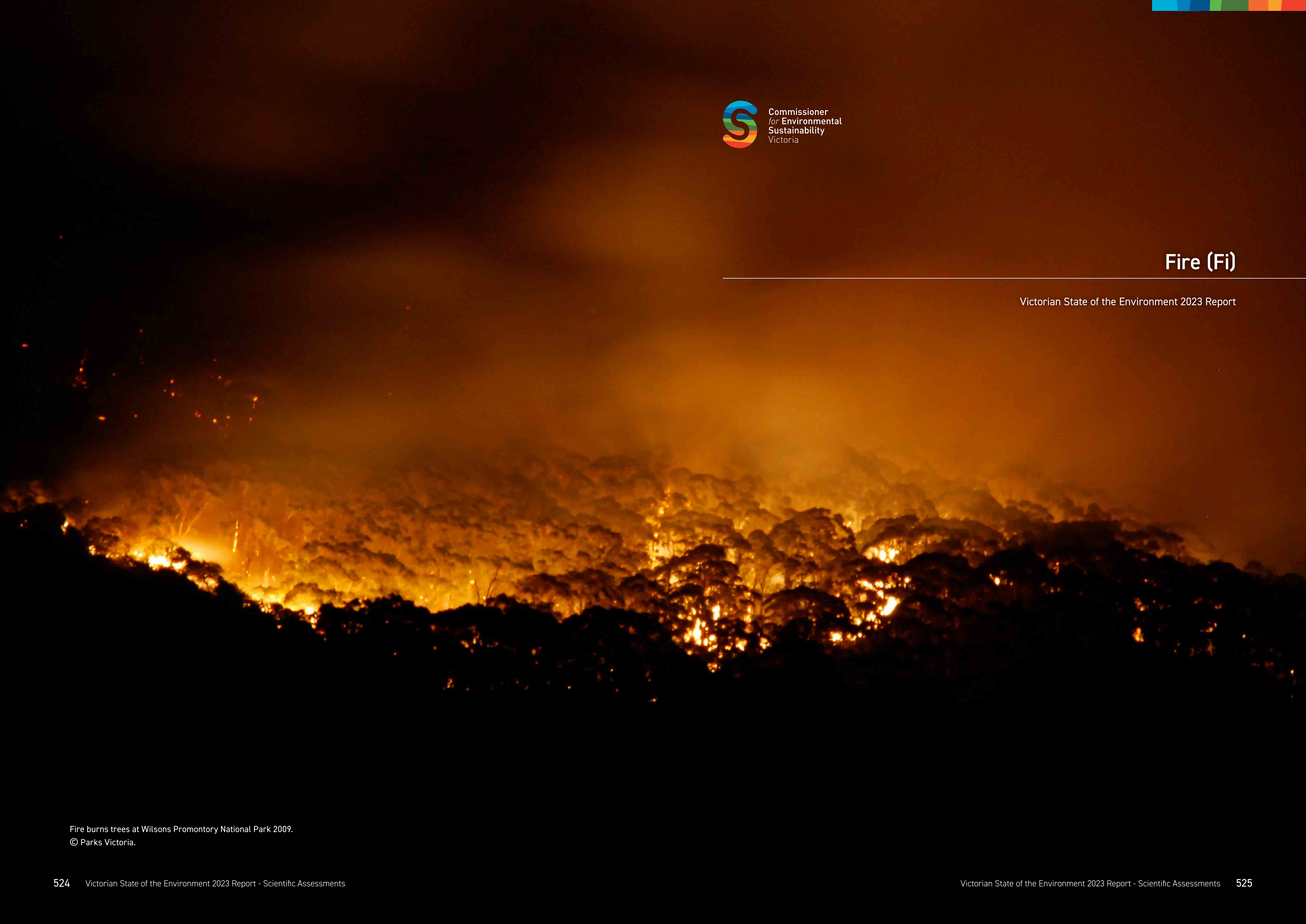

Commissioner
for Environmental
Sustainability
Victoria

Fire (Fi)

Victorian State of the Environment 2023 Report

Fire burns trees at Wilsons Promontory National Park 2009.
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Key findings

Fire regimes play a vital, yet complex, role in Victorian ecosystems that provide habitat for a diverse range of fire-adapted native flora and fauna species (with some plant species only germinating after stimulation by heat or smoke, for example). The beneficial effects of fire on ecosystem processes are well researched. Locally, fire catalyses plant nutrient cycles by decomposing organic materials into available nutrients that provide fertile soil conditions. Fire assists key processes within landscapes, for example, tree decay, tree collapse and stand tree germination.[1512, 1513, 1514, 1515] Unexpected or inappropriate fire regimes can jeopardise the survival of threatened flora and fauna species. These ecological complexities highlight the importance of optimising fire management in Victoria.

In terms of economic impacts, the Reserve Bank of Australia estimated that the 2019-20 bushfires would directly reduce growth in the national gross domestic product (GDP) by around 0.2% between December 2019 and March 2020.[1516] Westpac indicated that the 2019-20 bushfires would result in insured and uninsured losses oof around $5 billion nationally. Of this, around 8% was attributed to Victoria.[1517] The economic cost of bushfires is expected to double by 2050.

About a third of listed flora and fauna species under the *Flora and Fauna Guarantee Act 1988* (FFG Act) were severely impacted by the 2019-20 bushfires.[1518] There are 244 species that had at least 50% of their likely statewide habitat burnt, 215 of which are rare or threatened species. The unprecedented increase in the vulnerability of many species due to this single catastrophic event highlights how the 2019-20 bushfires were an ecological disaster of national and international importance. Many of Victoria's native species are vulnerable to increasing extinction risk and severe impacts of bushfire, which indicates that we need to improve strategies for prevention and response to mitigate future losses to bushfires.

It is expected that the area of native vegetation impacted by bushfire is likely to increase because of more frequent extreme weather events.[1519, 1520] This is consistent with the findings of the State of the Environment (SoE) 2018 Report. A higher probability of more frequent catastrophic bushfires presents a growing risk to threatened species that are likely to become even more vulnerable. Even some fire-tolerant vegetation types and ecological communities may face changes to their structural composition as a result of recurrent severe wildfires, making them more vulnerable to structural and state changes by killing seedlings and increasing tree mortality.[1521, 1522]

The Department of Energy, Environment and Climate Action (DEECA) uses a range of metrics to understand the impact of changing fire regimes on ecosystem resilience, including tolerable fire interval (TFI), growth stage structure and geometric mean of abundance. The SoE 2018 Report incorporated information on ecosystem resilience using these metrics for 2016–17, which indicated that about 54% (4,119,000 ha) of native vegetation across Victoria was below minimum TFI. In 2020–21 this had increased slightly to 55% (4,157,670 ha). However, in 2019-20, the area burnt by bushfires, while below minimum TFI (757,898 ha), was the greatest since 1980; and the long-term trend is a consistent increase in Victoria's land sitting

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[1516] Reserve Bank of Australia 2020, 'Statement of Monetary Policy – February 2020 – Box B: Macroeconomic effects of the drought and bushfires', https://www.rba.gov.au/publications/smp/2020/feb/box-b-macroeconomic-effects-of-the-drought-and-bushfires.html Accessed 24 August 2022.

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below minimum TFI. These areas are vulnerable to major — and potentially irreversible — changes in vegetation communities if they burn again in the next few decades. These trends indicate an increasing likelihood that some areas will experience localised extinctions of plant species.

To accurately quantify and track changes in ecological resilience, DEECA and external partners have developed a new set of metrics and targets that combine empirical, field-based observations and spatial modelling. DEECA advises these will be finalised as part of a review of bushfire metrics and targets, which is due to be completed later in 2023.

Planned burns have been a strategic tool to reduce bushfire risk and reduce the spread and intensity of bushfires when they occur. Since 2015–16, when the hectare-based target was set at burning 5% of public land each year, a risk-based approach has been adopted to fuel management on public land. DEECA's fuel management program aims to keep bushfire risk at or below 70% of Victoria's maximum bushfire risk. Maximum bushfire risk is calculated using a model that assumes the worst conditions are present, including maximum fuel build-up and extreme bushfire conditions. Victoria has succeeded in maintaining bushfire risk below 70% of the maximum since the risk target for the fuel management program was introduced.

Forest Fire Management Victoria and partner agencies undertake joint planning at both strategic and operational levels to inform the fuel management program. The Joint Fuel Management Program (JFMP) sets out the annual schedule of fuel reduction works (planned burning, slashing, mowing, and clearing). On average, planned burning accounted for more than two-thirds (70%) of the total risk reduction from July 2009 to June 2022, compared with 30% for bushfires. This is despite bushfires burning an additional 747,000 hectares compared to planned burning in that period. This is because planned burning uses best available science and data to target areas (such as those close to high-value assets) to maximise risk reduction, whereas bushfires randomly burn across locations.

Table Fi1: Fire indicators assessed in this chapter with comparisons to SoE 2018 assessments.

Fire

2023 Indicator	2023 status	2023 trend	2023 confidence	2018 Indicator	2018 status	2018 trend	2018 data quality
Fi:01 Area of native vegetation burnt in planned fires and bushfires	🔴 (bushfire) 🟡 (planned burn)	↙ (bushfire) → (planned burn)	🟢 (bushfire) 🟢 (planned burn)	Fi:01 Area of native vegetation burnt in planned fires and bushfires	🔴	↙	🟢
Fi:02 Impacts of bushfires	🔴	↙	🟢	Fi:02 Impacts of bushfires	🔴	?	🔴
Fi:03 Actual fire regimes compared to optimal fire regimes in public forests	🔴	↙	🟡	Fi:03 Actual fire regimes compared to optimal fire regimes	🟡	↙	🟢
Fi:04 Bushfire risk	🟡	↙	🟢	Fi:04 Bushfire risk	🟡	↙	🔴

Victorian Government progress on State of the Environment 2018 Report recommendations

The SoE 2018 Report included recommendations to the Victorian Government to improve environmental sustainability outcomes. Presented below is the recommendation specific to this theme as well as:

- the full government response to the recommendation, including the level of support, as published in the Victorian Government Response to the State of the Environment 2018 Report
- a description of progress made on the implementation of the recommendation over the past five years. The content of this section is derived from written material supplied directly to the Commissioner for Environmental Sustainability by relevant government entities and/or it synthesises information that is publicly available in referenced reports, legislation and websites. Importantly, this section summarises the progress made since 2018 in relation to the recommendation; it is not an audit of the extent and quality of the completed work.

Recommendation 8 of the SoE 2018 Report recommended:

> *That the Victorian Government establish a structured framework based on the findings of the dual-scale ecosystem resilience monitoring program, piloted by DELWP in 2017–18, and undertake a detailed analysis of the persistence of key fire-response species to increased fire frequency in Victoria, particularly in areas where below-minimum Tolerable Fire Interval (TFI) exists.*

Government response in 2020:

SUPPORT

> ‘The Victorian Government supports this recommendation. The state-wide ecosystem resilience monitoring program has commenced and surveys of the first two Ecological Fire Groups began in Spring 2019. These surveys will improve our knowledge of the effects of varying fire intervals on the persistence of key fire response species. This will allow a robust analysis of the changes to vegetation composition as a result of areas being burnt below the minimum Tolerable Fire Interval. This analysis and the results of the broader program will improve the conservation of threatened ecological communities and have implications for the way fire prevention activities, including controlled burns and mechanical fire prevention, are planned and implemented.’ [1523]

Progress made since 2018

DEECA has invested over $6.1 million in ecosystem resilience monitoring for all 11 of the scientifically recommended priority ecological fire groups (EFG’s). Victoria now has data for three of the highest priority EFGs, providing opportunities to replace expert elicited data sets with empirically derived data in their models and decision-making. These three EFGs were completed by La Trobe University. Surveys for other EFGs are underway — a draft final report for heathlands in general is being completed by the University of Melbourne.

This monitoring program is providing scientific evidence and recommendations for fire management and planning, the ecological basis underpinning Victoria’s ecosystem resilience metrics, and future monitoring and research. For example:

- enabling place-based decisions for the management of each EFG across the landscape, by understanding their ecological characteristics and how they respond to fire
- informing decisions regarding the makeup of each EFG
- informing decisions to change tolerable fire intervals and growth stages for a particular EFG, reducing risk to the landscape using more appropriate planned fire regimes
- informing future review of the method used to calculate tolerable fire intervals
- recommending program improvements such as the inclusion of additional stratifying variables, flexibility in survey design according to the EFG being surveyed, and future research projects.

1523. Department of Environment, Land, Water and Planning (DELWP) 2020, ‘Victorian Government response to the state of the environment 2018 report’, Melbourne, Victoria, https://www.environment.vic.gov.au/__data/assets/pdf_file/0017/504008/Victorian-Government-response-to-the-State-of-the-Environment-2018-report.pdf. Accessed 16 March 2023.

Fire

Background

Fire is ever-present in the Australian landscape and has been so for 145 million years.[1524] Iconic plants, such as some eucalypts, have evolved and adapted to the continent's dry and fire-prone environment, quickly re-sprouting or releasing seed after fire. Some banksias and hakeas also use fire to release their seeds into nutrient-rich ash beds where they can germinate.

Fire can open the canopy, allowing direct sunlight to reach the ground and encourage plant germination. Fire can hollow out trees and logs, which become nesting sites for native animals, and burn out existing hollows. Fires also results in the collapse of existing large, old trees that may be providing hollows, such as standing dead trees. However, fires can also severely impact native plants and animals, especially when they are as intense and extensive as those in the 2019–20 summer. The immediate and direct impact for wildlife can be death from incineration, radiant heat and smoke inhalation. Following the fire, survival can also be threatened due to the loss of food and shelter, habitat fragmentation and predation.

When fires are too severe, or too frequent, plants and their communities can suffer. Frequent fires can deplete seed banks if seedlings are unable to reach seed-producing maturity before the next fire. Surviving plants can be exposed to feral herbivores, such as rabbits and deer, and forced to compete with weeds, such as blackberries. Vegetation communities that lack resilience to frequent fires, such as in alpine areas and rainforests, may take hundreds of years to recover.[1525] The large canopy trees in rainforests are often fruit bearing and an important food source for animals reliant on unburnt habitats. Fire also impacts on soil nutrients, especially carbon, nitrogen and phosphorus. The relative impact of any given fire on the nutrient pool will be potentially greater where the fire is severe.

Victoria is one of the world's most fire-prone regions and where two-thirds of all Australian bushfire deaths have occurred since 1900.[1526] The Forest Fire Management Victoria website lists 32 major bushfires between Black Thursday 1851 and 2013, including Red Tuesday 1898, Black Friday 1939, Ash Wednesday 1983 and Black Saturday 2009.[1527] Figure Fi1 maps the location and frequency of Victorian bushfires between 1995 and 2020.

For the Country Fire Authority (CFA), Black Saturday 2009 was 'a unique and devastating event that changed Victoria and CFA forever'.[1528] In response to that devastating fire, which claimed the lives of 173 people, changes were made to fire mapping, modelling and warnings, fuel management, building codes, the fire danger rating system (a 'Code Red' or 'Catastrophic' rating was added) and bushfire risk assessment in Victoria.

While these changes were being made, bushfires were also changing, driven by the drier, hotter and stormier conditions generated by climate change.[1529, 1530, 1531] In 2008, the Garnaut climate change review reported that:

> 'Fire seasons would start earlier, end slightly later, and generally be more intense. This effect increases over time but should be directly observable by 2020.' [1532]

Research indicates the severity, extent, frequency and duration of bushfires have all increased, with long-term changes in fire weather conditions now apparent in south-eastern Australia, including Victoria. There is a clear trend toward more dangerous fire weather conditions during spring and summer, with an increased frequency and magnitude of extremes, as well as an earlier start to the fire season. The window for undertaking fuel management via planned burning is also shifting.

[1524] Clarke MF 2020, 'Our birds will be ok, they've evolved to cope with fire... haven't they?', *Emu*, 120, pp. 184-186.

[1525] Forbes T, Tatham H 2018, 'From rainforest to cinders: National park may take "hundreds of years" to recover from bushfire disaster', ABC Tropical North, https://www.abc.net.au/news/2018-12-04/eungella-rainforest-future-questioned-by-expert/10578802 Accessed 4 December 2018.

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Fire

In Victoria, planned burns are conducted during autumn (March-May) and early spring (September), and rarely during winter (June-August). However, with climate change, these windows are projected to decrease during the months typically used for planned burns but may increase in the winter months and later into spring (September - October).[1533]

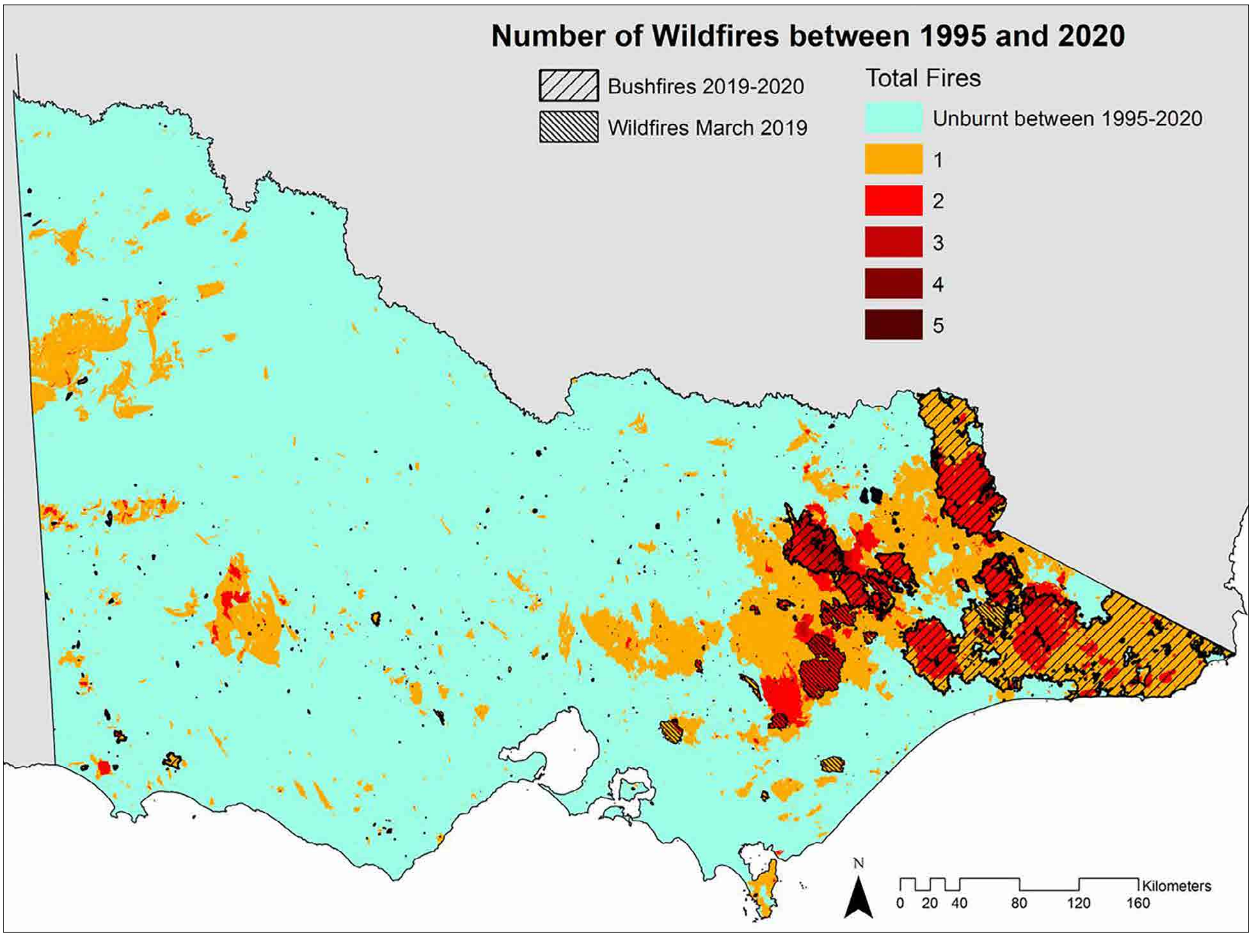

Figure Fi1: Number of wildfires in Victoria from 1995 to 2020.[1534]

The 2019–20 bushfires occurred during Australia's hottest year on record. December 2019 was also the hottest of any December. Increases in the Forest Fire Danger Index (FFDI; calculated using rainfall, evaporation, wind speed, temperature and humidity data) have been predicted by scientists over the past three decades, including in 1995, 2001, 2007, and 2011, as well as by Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BOM) in 2015.[1535, 1536, 1537, 1538,1539] The two national scientific organisations predicted severe fire days would increase from between 160% and 190% by 2090 compared to 2020.

1533. Di Birgilio G, Evans JP, Clarke H, Sharples J, Hirsch AL, Hart MA 2020, 'Climate change significantly alters future wildfire mitigation opportunities in southeastern Australia', *Geophysical Research Letters, 47, e2020GL088893.*
1534. Lindenmayer D, Taylor C 2020, 'New spatial analyses of Australian wildfires highlight the need for new fire, resource, and conservation policies', *PNAS*, 117, pp. 12481–12485.
1535. Beer T, Williams A 1995, 'Estimating Australian forest fire danger under conditions of doubled carbon dioxide concentrations', *Climatic Change*, 29, pp. 169–188.
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1538. Clarke H, Smith P, Pitman A 2011, 'Regional signatures of future fire weather over eastern Australia from global climate models', *International Journal of Wildland Fire*, 20, pp. 550–562.
1539. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Bureau of Meteorology (BOM) 2015, 'Climate change in Australia: Information for Australia's Natural Resource Management Regions', Technical Report, Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Bureau of Meteorology (BOM), Australia.

Fire

Policy and legislative settings

The Secretary of DEECA has powers and duties relating to the use and management of fire on public land. These arise from both the *Forests Act 1958* and *Conservation Forests and Lands Act 1987.* The Code of Practice for Bushfire Management on Public Land 2012 (amended 2022) is established under the latter act to guide the Department's activities.

The Code sets two key objectives:

- to minimise the impact of major bushfires on human life, communities, essential and community infrastructure, industries, the economy and the environment. Human life will be afforded priority over all other considerations.
- to maintain or improve the resilience of natural ecosystems and their ability to deliver services such as biodiversity, water, carbon storage and forest products.

It also sets out a range of processes and structures to support DEECA to meet its legislative responsibilities. This includes a requirement that DEECA conducts strategic bushfire management planning to develop regional Bushfire Management Strategies. Since European occupation, biota has changed, due to weed invasion and grazing regimes, and climate is also changing to become more fire-inducing. Despite these adverse current trends, it remains clear that land management is crucial to both objectives. Further, it is becoming increasingly evident that future land management should be informed by, if not based around, aspects of Traditional Owner land management.

The Code is currently under review with a view to it being updated and rewritten by 2024.

Launched in 2015, Victorian State's Safer Together is a multi-agency program which aims to reduce bushfire risk in Victoria. A focus is to work collectively across land tenures to manage bushfire risk to protect communities, critical infrastructure, the environment and other values. A residual risk reduction target is used when identifying areas where bushfire management activities, such as planned burning, will have the greatest effect on reducing risk to life and property.

Regional Bushfire Management Strategies are developed through the strategic bushfire management planning process to meet the Code objectives and Safer Together policy intent. DEECA works with sector partners, such as Parks Victoria, to develop strategies for public and private land across shared regional planning footprints.

The Bushfire Management Strategies identify where important values and assets are located across the landscape. It considers the current extent and quality of these values and, where possible, considers future trends including population, industry, and environmental change. Strategic planning identifies objectives for the important values and assets and develops an approach to manage the risks posed to them. The resulting bushfire management strategies describe cross-tenure landscape zones that focus fuel management activities to deliver bushfire risk reduction and ecological outcomes and are implemented through operational programs, such as the Joint Fuel Management Program.

The Joint Fuel Management Program aims for an integrated and risk-focused fuel management program across public and private land. It is designed to implement long-term strategic bushfire management strategies, which outline how the risk of bushfires is managed for the protection of life and property on public and private land, while maintaining and improving natural ecosystems.

Fire

The Emergency Management Act 2013 establishes governance arrangements for emergency management in Victoria. This includes the establishment of Emergency Management Victoria (EMV), which leads the Victorian Government's emergency management reform agenda and the Inspector-General for Emergency Management. The Emergency Management Act defines key elements of Victoria's emergency management structure, assigns roles and responsibilities, and clear accountability regarding the management of major emergencies, including the definition of major fire. In 2018, the *Emergency Management Legislation Amendment Act 2018* was passed through the Parliament of Victoria to establish new integrated, coordinated and comprehensive arrangements for emergency management planning at the regional level. This legislation fully came into effect on 1 December 2020.

These is an increasing amount of scientific evidence that supports not only cultural recognition of Traditional Owner land management, such as mosaic burning of grasslands, but also the increasing understanding of how it made the landscape ecologically more productive while also reducing the risk of large-scale bushfires across Australia, including Western Australia,[1540] New South Wales and Victoria.[1541, 1542] To reflect this, the Victorian Traditional Owner Cultural Fire Strategy was released in 2018 'to reinvigorate cultural fire through Traditional Owner led practices across all types of Country and land tenure; enabling Traditional Owners to heal Country and fulfil their rights and obligations to care for Country.'[1543]

The strategy's vision is that:

> 'Future generations of Victorian Traditional Owners will grow up observing their Elders leading the use of the right fire for Country. They will be trusted to know the special reasons why fire is used and how it brings health to the land and people. Their children and grandchildren will see culturally valuable plants and animals return to Country and know their stories.' [1544]

The strategy has four objectives which are to:

- develop operational pathways that enable Traditional Owners to lead the planning and to undertake cultural burns across all land tenures and Country types according to their cultural obligations
- build Traditional Owner governance and capacity in cultural fire knowledge and practice
- improve the management of state forest reserves and private land though the application of collaborative management to heal country and build resilience in people and landscapes
- facilitate the development and strengthening of institutional frameworks that support cultural fire practice.

[1540] Bird RB, Taylor N, Codding BF, Bird DW 2013, 'Niche construction and Dreaming logic: aboriginal patch mosaic burning and varanid lizards (*Varanus gouldii*) in Australia', *Proceedings of the Royal Society Biological Sciences*, 280, pp. 20132297.

[1541] Fletcher MS, Romano A, Connor S, Mariani M, Maezumi SY 2021, 'Catastrophic bushfires, Indigenous fire knowledge and reframing science in southeast Australia', *Fire*, 4, pp. 61, https://doi.org/10.3390/fire4030061 Accessed 24 April 2023.

[1542] Mansergh IM, Cheal DC, Burch JW, Allen HR 2022, 'Something went missing: Cessation of traditional Owner land management and rapid mammalian population collapses in the semi-arid region of the Murray-Darling Basin, southeastern Australia', *Proceedings of the Royal Society of Victoria*, 134(1), pp. 45-84.

[1543] Victorian Traditional Owner Cultural Fire Knowledge Group 2018, 'The Victorian Traditional Owner cultural fire strategy', Federation of Victorian Traditional Owner Corporations, Melbourne, Victoria.

[1544] Ibid.

Indicator assessments

Refer to ‘Guide to the indicator assessments’ at the start of Part 3 for the accompanying definitions and legends related to the indicator assessment summary tables.

Indicator Fi:01 Area of native vegetation burnt in planned fires and bushfires

Fi:01 Area of native vegetation burnt in planned fires and bushfires

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴 (bushfire) 🟡 (planned burn)	↙ (bushfire) → (planned burn)	🟢 (bushfire) 🟢 (planned burn)	🔴	↙	🟢
Data source(s):	DELWP					
Measure(s):	Annual planned burn area on public land Annual total area affected by bushfires					

Why this indicator?

This indicator provides a baseline for the spatial extent and nature of planned burns and bushfires, which is also used to calculate residual risk. As planned burns and bushfires have different distinctive aspects to assess, each are considered separately. This indicator does not evaluate the impact of planned burn and bushfires on environmental values; these are discussed within indicators Fi:02, Fi:03 and Fi:04.

Why this assessment in 2023?

The average annual area of the bushfire extent has increased in the past 20 years. Although bushfire is an important tool for land management, excessive bushfire impacts – with increasing fire intensity and frequency – result in deterioration of environmental, social and economic outcomes in Victoria. CSIRO indicates that these impacts could be worsened by rapidly changing fire weather, so this indicator is assessed as poor. Victoria's bushfire risk has been maintained below 70% of its maximum bushfire risk since the introduction of the risk target for the fuel management program in 2016–17. On average, planned burning accounted for more than two-thirds (70%) of the total risk reduction compared to 30% for bushfires.

Bushfires have a negative impact on native vegetation because of the extent and frequency of burning. The most recent example is the 2019–20 bushfires. Research indicates that the average bushfire extent could increase as the fire season lengthens due to hotter and drier conditions: the window for planned burning is narrowing. This trend is primarily due to anticipated rapid changes of climate, leading to fewer suitable days (in terms of weather and fuel conditions) for planned burns relative to historical records. This suggests that the trend could continue to deteriorate.

Summary of State of the Environment 2018 Report assessment

- The area of annual planned burns had been decreasing since 2012-13 due to a range of factors, including policy changes (in particular, a shift to a risk-based rather than an area-based target), weather and other operational constraints.
- The area-based target (5% annual burn of public land) had concluded in 2016-17 and a risk-based approach had commenced.

Critical data used for the 2023 assessment

- Annual planned burn area
- Annual total area affected by bushfires
- Planned burn areas treated compared to total area planned for treatment

Fire

2023 assessment

Figure Fi2 presents data on bushfires in Victoria from 2000 to 2021. The largest area burnt occurred in 2020, which is the result of a catastrophic large-scale fire during 2019-20. Victoria's 2019-20 bushfires commenced on 21 November 2019, with an estimated 60 fires across the state. The last major fire complex in East Gippsland was declared contained three months later, on 27 February 2020, with more than 1.5 million hectares having been burnt, including nearly 1.39 million hectares of native forest or 18% of Victoria's public native forests. The area most impacted by the bushfires was the East Gippsland RFA region, where over 67% of the total area and 70% of the forests were burnt. The East Gippsland fires, covering the East Gippsland and Gippsland RFAs, impacted many communities within these areas, in particular, Mallacoota, Genoa, Cann River, Orbost, Goongerah, Wairewa, Sarsfield, Bruthen, Tambo Crossing, Swifts Creek, Omeo and Buchan.[1545] Significantly large areas were also burnt at high severity. Around 750,000 hectares of public land was impacted by the bushfire. More than half of the burnt area was concentrated on the East Gippsland area.[1546]

In the Western RFA region, two bushfires burnt a total of 5,179 hectares of the Budj Bim Cultural Landscape, which is 64% of the United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage site. In all, more than 60,000 people were estimated to have evacuated from the East Gippsland and Hume regions. The 2019-20 bushfires burnt the largest area since 2000. Prior to 2000, the only fire that had reached a scale similar to the 2019-20 bushfires was the Black Friday bushfire in 1939. At a national scale, CSIRO's new analyses of Australian forest fire confirmed that the 2019-20 bushfires are part of a clear trend of worsening fire weather and ever-larger forest areas burnt by fires.[1547]

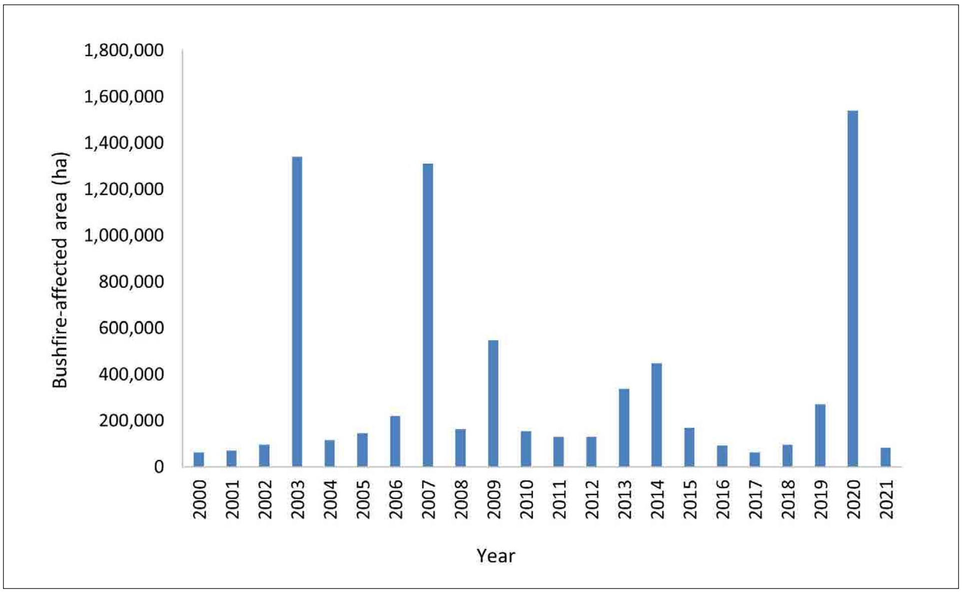

Figure Fi2: Total area affected by bushfires in Victoria from 2000 to 2021.[1548]

[1545] Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires – Summary report: Information and data to inform public consultation', Melbourne, Victoria, https://www.deeca.vic.gov.au/__data/assets/pdf_file/0023/542156/Summary_Report_May_2021_-_Accessible_Version_002.pdf Accessed 8 May 2023.

[1546] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires' https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

[1547] Canadell JG, Meyer CP, Cook GD, Dowdy A, Briggs PR, Knauer J, Pepler A, Haverd V 2021, 'Multi-decadal increase of forest burned area in Australia is linked to climate change', *Nature Communication*, 12, pp. 6921, https://doi.org/10.1038/s41467-021-27225-4 Accessed 24 April 2023.

[1548] Forest Fire Management Victoria, 'Bushfire risk to life and property and ecological values', https://www.ffm.vic.gov.au/fuel-management-report-2020-21/statewide-achievements/bushfire-risk Accessed 18 April 2023.

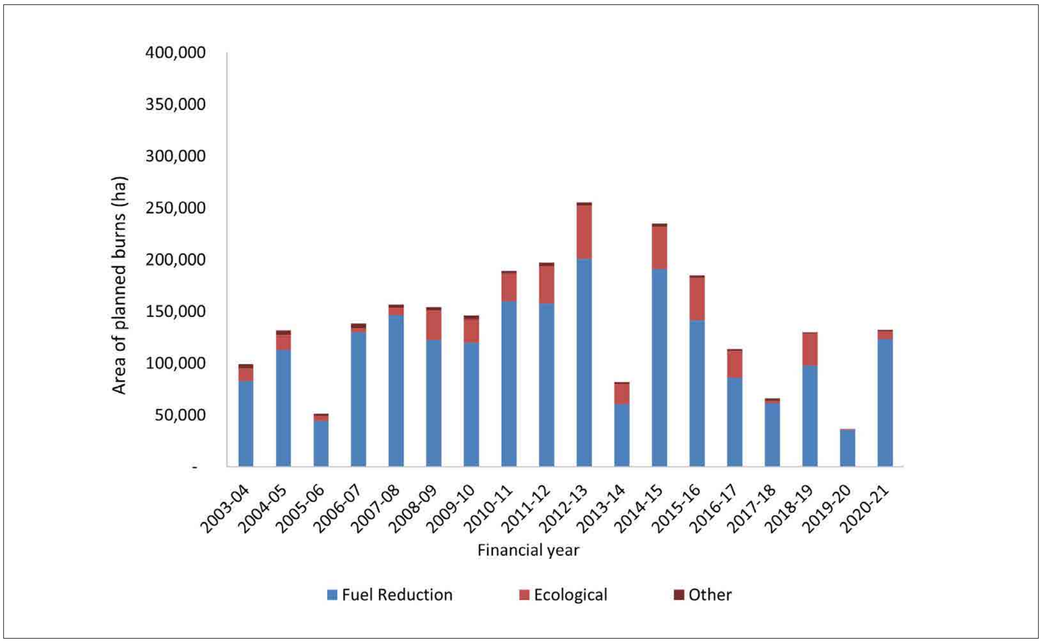

Figure Fi3: Area of planned burns in Victoria from 2003-04 to 2020-21. Planned burns aimed at reducing fuel levels are shown in blue. Planned burns aimed at achieving ecological objectives are shown in light red. Planned burns denoted as 'other' include regeneration and catchment protection burns and are shown in dark red.[1549, 1550, 1551, 1552, 1553]

Prescribed (planned) burning is an important element in managing risks to the Victorian economy, society and environment into the future, and will be an essential element to manage fire within forests and other vegetation communities at the landscape scale. The area of planned burning (also known as prescribed burning and hazard reduction burning) has been variable between 2003-04 and 2020-21, with the largest areas burnt in the 2012-13 (Figure Fi3). Since 2015–16, the hectare-based target has shifted from a hectare-based approach to a risk-based approach for fire management. Currently, DEECA sets a residual bushfire risk target across the state, as well as for regions. DEECA released new analyses that show the relative contributions of planned burning and bushfires to risk reduction.[1554] Between 2009 and 2021, planned burning accounted for around two-thirds (70%) of the total risk reduction, compared to one-third (30%) for bushfires. This risk reduction was achieved while bushfires burnt 747,000 hectares more than planned burning. DEECA claims that planned burning has been effective in reducing bushfire risks to human life, environment, infrastructure and economy.
To better understand this, the Commissioner for Environmental Sustainability further requested an alternative reporting approach which includes an analysis of absolute risk reduction effect over a period and the delineation of the contribution of fuel management and bushfire. DEECA advised that the additional analysis would require a comparison between multiple scenarios (a landscape with no fire history and landscapes with either a history of bushfire or planned burning) that is then validated by research experts, which could not be delivered with the available resources and within the timeframe needed to include in this SoE 2023 Report.[1555]

[1549] Commissioner for Environmental Sustainability (CES) 2018, 'State of the environment 2018 report', Melbourne, Victoria.

[1550] Department of Environment, Land, Water and Planning (DELWP) 2018, 'Managing Victoria's bushfire risk: fuel management report 2017-18', Melbourne, Victoria.

[1551] Forest Fire Management Victoria, 'Fuel management report 2018-19: Fuel management activities', Melbourne, Victoria, https://www.ffm.vic.gov.au/fuel-management-report-2018-19/statewide-achievements/fuel-management-activities Accessed 2 May 2023.

[1552] Forest Fire Management Victoria, 'Fuel management report 2019-20: Fuel management delivery', Melbourne, Victoria, https://www.ffm.vic.gov.au/fuel-management-report-2019-20/statewide-achievements/fuel-management-activities Accessed 2 May 2023.

[1553] Forest Fire Management Victoria, 'Fuel management report 2020-21: Fuel management delivery', Melbourne, Victoria, https://www.ffm.vic.gov.au/fuel-management-report-2020-21/statewide-achievements/fuel-management-activities Accessed 2 May 2023.

[1554] Forest Fire Management Victoria, 'Fuel management report 2020-21: Bushfire risk to life and property and ecological values', Melbourne, Victoria, https://www.ffm.vic.gov.au/fuel-management-report-2020-21/statewide-achievements/bushfire-risk Accessed 5 May 2023.

[1555] Department of Energy, Environment, and Climate Action (DEECA), 'Unpublished data', Melbourne, Victoria, Accessed 2023.

CSIRO found that there is a 300% to 500% increase in burnt area for every extra day of severe fire danger, and a 21% increase in burnt area for every extra day of very high fire danger.[1556] This is related to a critical change in what factor drives fire spread above a severe FFDI. Research on the effect of prescribed burning on bushfire severity from the 2003 fires in Victoria found that landscape-scale fires became 'weather-dominant' from FFDI 50 (severe), and fuel and topography became less important to continued fire spread.[1557] FFDI has been steadily worsening over the past 40 years.[1558] This provides critical implications for planned burning as greater use of prescribed burning to reduce and wildfire risks and impacts would be required to mitigate more frequent severe or higher FFDI. This should not be achieved by simply committing increasing resources to wildfire suppression.[1559]

Another point to consider for the future delivery of planned burning is the impacts of climate change. The Climate Council of Australia indicates that climate change is driving warmer and drier conditions, lengthening the fire season, increasing fire danger, and reducing the time available for planned burning.[1560] However, modelling by Clarke et al (2019) and di Virgilio et al (2020) suggests that, as the autumn or spring window closes for planned burning, a winter window could be opening. [1561, 1562] It is important to understand the implication of climate change on the availability of planned burn activities.

Victoria's 3-year Joint Fuel Management Program (2020–21 to 2022–23) covers private and public land and outlines the importance of planned burning in achieving its targets. Forest Fire Management Victoria actively engages with Traditional Owners about the level of involvement they wish to have in supporting the planning for, and delivery of, the statewide planned burning program. In the spirit of self-determination, it is not appropriate to assume or expect that Traditional Owners would be interested or be in a position to substantially deliver or co-deliver the statewide program. Importantly, Traditional Owners conduct cultural burns for a range of objectives, including protecting biodiversity and harvesting food. While cultural burns can also help to reduce bushfire risk, this is not necessarily the primary objective.

DEECA supports Traditional Owners to conduct cultural burns in accordance with their objectives. For 2020–21, there were 202 cultural burn events planned in partnerships between land management agencies and Traditional Owners. As part of the 2021-22 budget, the Victorian Government allocated $22.5M over four years to reinvigorate Traditional Owner-led cultural land and fire management practices.

Cultural burns are also being conducted by Traditional Owners in partnership with catchment management authorities (CMAs). The Red Tails of the Glenelg Plain Burning Project, a partnership between the Gunditjmara Traditional Owners and the Glenelg Hopkins CMA, is monitoring the results of a cultural burn on 16 hectares of habitat for the south-eastern red-tailed black cockatoo (*Calyptorhynchus banksii graptogyne*) in Nangeela State Forest, south-western Victoria. It is hoped that the cultural burn will reduce the site's flammability without impacting the cockatoo population.[1563] The Gunditjmara Traditional Owners, along with the Budj Bim Rangers, also conducted a cultural burn in the Tyrendarra Indigenous Protected Area in 2019 to reduce phragmites reed growth, improve the habitat for the Australasian bittern (*Botaurus poiciloptilus*), develop cultural skills and regenerate habitat for native species (dense reeds can dry out the wetland and reduce connectivity for eels, frogs and fish).[1564]

1556. Cook G, Dowdy A, Knauer J, Meyer M, Canadell P, Briggs P 2021, 'Australia's Black Summer of fire was not normal - and we can prove it', the Conversation, https://theconversation.com/australias-black-summer-of-fire-was-not-normal-and-we-can-prove-it-172506 Accessed 27 October 2022.
1557. Tolhurst K, McCarthy G 2016, 'Effect of prescribed burning on wildfire severity: a landscape-scale case study from the 2003 fires in Victoria', *Australian Forestry*, 79(1), pp. 1-14, DOI: 10.1080/00049158.2015.1127197. Accessed 26 April 2023.
1558. Cook G, Dowdy A, Knauer J, Meyer M, Canadell P, Briggs P 2021, 'Australia's Black Summer of fire was not normal - and we can prove it', The Conversation, https://theconversation.com/australias-black-summer-of-fire-was-not-normal-and-we-can-prove-it-172506 Accessed 27 October 2022.
1559. Morgan G, Tolhurst K, Poynter M, Cooper N, McGuffog T, Ryan R, Wouters M, Stephens N, Sheehan B, Leeson P, Whight S, Davey S 2020, 'Prescribed burning in south-eastern Australia: history and future directions', *Australian Forestry*, 83:1, pp. 4-28, DOI: 10.1080/00049158.2020.1739883 Accessed 26 April 2023.
1560. Climate Council of Australia 2020, 'Factsheet: setting the record straight on hazard reduction burning', Sydney, New South Wales.
1561. Clarke H, Tan B, Boer M, Price O, Kenny B, Bradstock R 2019, 'Climate change effects on the frequency, seasonality and interannual variability of suitable prescribed burning weather conditions in southeastern Australia', Agricultural and Forest Meteorology, 271, pp. 148–157.
1562. Di Virgilio G, Evans J, Clarke H, Sharples J, Hirsch A, Hart M 2020, 'Climate change significantly alters future wildfire mitigation opportunities in southeastern Australia', Faculty of Science, Medicine and Health, University of Wollongong, Wollongong, New South Wales.
1563. Zeeman B, King M 2020, 'Red tails of the Glenelg Plain Burning Project', Glenelg Hopkins Catchment Management Authority, Hamilton, Victoria.
1564. Glenelg Hopkins Catchment Management Authority 2019, 'Cultural burns benefit more than just Bittern', Media release 27 June 2019.

Indicator Fi:02 Impacts of bushfires

Fi:02 Impacts of bushfires

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴	↙	🟢	🔴	?	🔴

Data source(s):	DJPR, Inspector-General of Emergency Management, Insurance Council of Australia
Measure(s):	Impacts of bushfires on human settlements, human loss, businesses and natural resources

Why this indicator?

This indicator is used to monitor and evaluate the cumulative impacts of bushfires on communities. The Victorian Government's highest priority in bushfire management is the protection of human life. Impact of bushfire on natural resources is discussed in 'Fi:03 Actual fire regimes compared to optimal fire regimes in public forest'.

Why this assessment in 2023?

The status for bushfire impacts in Victoria over the past two decades is poor due to the 2019–20 bushfires and other devastating bushfires.

A comparison between bushfire data from the past two decades with that for the 20th century suggests that the trend in the status of bushfire impacts could be deteriorating. Predictions of increasing bushfire severity, duration, frequency and extent would also suggest a deteriorating trend.

Data for the 2019–20 bushfires were largely sufficient to assess their impact on Victoria's economy and community. Most literature, reports and inquiries provided prospects of the future impacts of bushfires.

Summary of State of the Environment 2018 Report assessment

- The Bushfire Co-operative Research Centre was the leading agency collating evidence on bushfire impact.
- Since 2013, there had been a lack of clarity regarding responsibility for data collation and dissemination to utilise for evidence-based future decision-making. Fragmented information only had been identified from EMV and the Department of Health.

Critical data used for the 2023 assessment

- Social and Economic costs of the 2019-20 bushfires in Victoria
- Estimated sawlog losses within the fire-affected RFA regions
- Areas burnt, number of lives lost, and number of homes lost in some significant bushfires between 1939 and 2019-20

2023 assessment

Since 2018, the major bushfires that impacted Victoria occurred in 2019-20. The Inspector-General for Emergency Management's Phase 1 report has data on the environmental, economic and social effects of the 2019–20 bushfires in Victoria (Table Fi2).[1565]. The economic sectors most impacted by the 2019–20 bushfires were tourism, agriculture, forestry, winemaking and beekeeping. More than 700 properties were also heavily impacted by the 2019-20 bushfires. Except for estimates of the economic impact on tourism, data on the impacts 2019-20 bushfires are limited, although insurance claims can provide some insight. The Insurance Council of Australia reported in May 2020 that Victorian bushfire-related insurance claims had reached $186 million.[1566] The organisation also indicates that bushfire-related claims of loss across Australia have been increasing dramatically (Figure Fi4). However, these losses do not include the economic impacts on soil for agricultural purposes.

1565. Inspector-General of Emergency Management 2020, 'Inquiry into the 2019–20 Victorian fire season: Phase 1 community and sector preparedness for and response to the 2019–20 fire season', Melbourne, Victoria.

1566. Insurance Council of Australia 2020, 'Insurance bill for season of natural disasters climbs over $5.19 billion, https://insurancecouncil.com.au/wp-content/uploads/resources/Media%20releases/2020/2020_05/2020_05_Insurance%20bill%20for%20season%20of%20natural%20disasters%20climbs%20over%20$5.19b.pdf Accessed 10 May 2021.

Table Fi2: Social and economic costs of the 2019-20 bushfires in Victoria.[1567]

Impacts	Statewide	Gippsland region	North East and Alpine regions
Hectares burnt (ha)	1,507,895	1,163,248	319,401
Native forest burnt (ha)	1,387,000	n/a	n/a
Deaths	5	4	1
Primary residences destroyed/damaged	313	n/a	n/a
Non-Primary residences destroyed/damaged	145	n/a	n/a
Livestock lost	6,829	1,152	4,135
Softwood Plantations (ha)	831	10	821
Crops (ha)	n/a	19,089	20,765
Sheds	n/a	232	246
Properties registered for clean-up	745	550	189
Tourism (January-March) $ million	330-350	n/a	n/a

Bushfires can impact water quality. The University of Melbourne researchers advised the Independent Panel, who were formed to undertake a review of the 2019-20 bushfires impact on Victoria's RFAs, that severe erosion events occurred in the Upper Murray and Tambo catchments.[1568] A report on the sediment quality in Lake Hume and its catchments between January 2020 and May 2022 found that approximately 830,000 tonnes of sediment have entered Lake Hume from the Murray River since the fires.[1569] This is nine times higher than the long-term average and resulted in above average loads of nutrients, particularly soluble reactive phosphorus and total phosphorus, entering Lake Hume. Water supply was minimally affected by the 2019-20 bushfires. This is because a mixture of high and moderate severity fires balanced out positive and negative streamflow, respectively.[1570] This analysis considered impacts on streamflow for ash-type and mixed-type forests because of the variability in severity of fire intensity. Uncertainty in this analysis was the impact of high-frequency and high-severity fires on mixed species — as this worsening fire regime could trigger species transition.[1571]

[1567] Inspector-General of Emergency Management 2020, 'Inquiry into the 2019–20 Victorian fire season, Phase 1 Community and sector preparedness for and response to the 2019–20 fire season', Melbourne, Victoria.

[1568] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires' https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

[1569] Baldwin DS 2022, 'Third interim report on the impacts of bushfires on water and sediment quality in Lake Hume and its catchment: January 2020 to May 2022', A report prepared for the Murray-Darling Basin Authority, pp. 50.

[1570] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires' https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf. Accessed 21 November 2022.

[1571] Ibid.

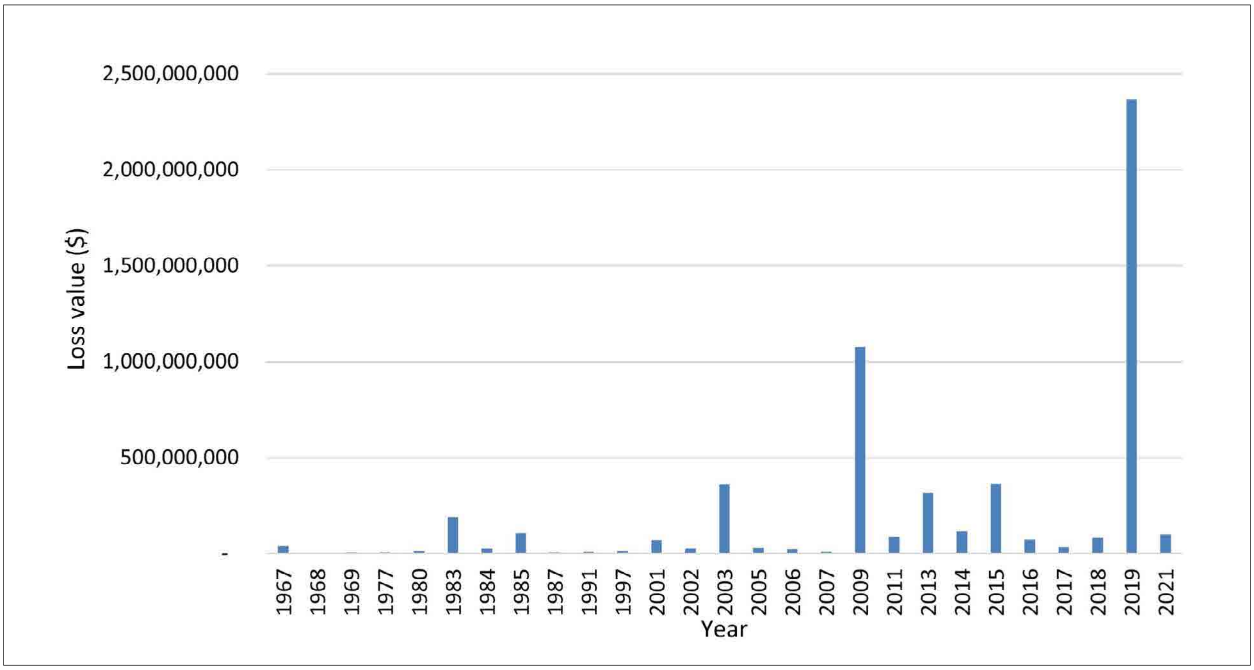

Figure Fi4: Insurance claims of loss that are related to bushfire in Australia from 1967 to 2021.[1572]

Along with the direct impacts at the fire front, the spread of smoke and ash to populated rural and urban areas beyond the fire zone also caused serious health impacts.[1573] The 2019-20 bushfires were estimated to be a major anomaly of bushfire-smoke-related health burden and costs in Australia when compared to the most recent 20 fire seasons.[1574] The University of Tasmania calculated that $1.95 billion on smoke-related health costs is more than nine times the median annual bushfire-associated costs for the previous 19 years of $211 million.[1575] Further, the research indicated that there is potential for dramatic rises in smoke impacts as the frequency and intensity of bushfires are estimated to increase.

The Victorian Department of Treasury and Finance indicated that, together with direct impacts (capital destruction and labour productivity losses) and indirect impacts (international tourism), the economic impact of the 2019-20 bushfires is estimated to be an approximately 0.1% reduction in Victoria's real gross state product in 2019-20.[1576] The overall welfare losses to Victoria are estimated to be $2.1 billion in net present value terms (in real 2017-18 dollars), with around 70% of the total economic impacts attributed to the assumed effects of the bushfires supressing international tourism to Victoria. Around 30% of economic losses are attributed to the two fire-affected regions, East Gippsland and North East Victoria. However, actual economic impact could be far worse if longer-term costs, such as ongoing physical and mental health issues, damage to ecosystems, including water resources, downgraded tourism activity, increased costs of living in bushfire-prone areas and reduced consumer confidence, are incorporated.

[1572] Insurance Council of Australia, 'ICA historical catastrophe list', https://insurancecouncil.com.au/wp-content/uploads/2022/08/ICA-Historical-Catastrophe-List-July-2022.xlsx. Accessed 30 August 2022.

[1573] Australian Institute of Disaster Resilience 2020, 'Australian Disaster Resilience Knowledge Hub: Bushfires black summer, Victoria, November 2019–February 2020, https://knowledge.aidr.org.au/resources/black-summer-bushfires-vic-2019-20/ Accessed 10 May 2021.

[1574] Johnston FH, Borchers Arriagada N, Morgan GG, Jalaludin B, Palmer AJ, Williamson GJ, Bowman DM 2020, 'Unprecedented health costs of smoke-related PM2.5 from the 2019–20 Australian megafires', *Nature Sustainability*, pp. 1–6.

[1575] University of Tasmania 2020, 'Smoke-related health costs of 2019-20 bushfires estimated at $1.95 billion', Hobart, Tasmania, https://www.menzies.utas.edu.au/news-and-events/media-releases/2020/smoke-related-health-costs-of-2019-20-bushfires-estimated-at-$1.95-billion#:~:text=at%20%241.95%20Billion-,Smoke%2Drelated%20Health%20Costs%20of%202019%2D20%20Bushfires%20Estimated%20at,climb%20to%20AU%241.95%20billion. Accessed 2 May 2023.

[1576] Department of Treasury and Finance (DTF) 2021, 'The economic impacts of the 2019-20 bushfires on Victoria', Melbourne, Victoria. https://www.dtf.vic.gov.au/sites/default/files/document/Victoria%27s%20Economic%20Bulletin%20Volume%205.pdf Accessed 16 August 2022.

Fire

The 2019–20 bushfires had an immediate impact on the operable inventory of VicForests, reducing the future volume of D+ grade sawlog available for harvest by approximately 9% in ash forests and approximately 13% in mixed species forests. About 1 million m^3 of D+ standing potential sawlogs were burnt or destroyed by the bushfires, of which, about 36% was ash sawlog and 64% was mixed species sawlog (Table Fi3). VicForests estimated impact on standing sawlog gross volumes is shown in Table Fi3 by forest type for each of the fire-affected RFA regions.[1577] Some of these burnt sawlogs were, however, able to be utilised during the salvage timber harvesting operations.

Table Fi3: Estimated sawlog losses within the fire-affected RFA regions as at August 2021.[1578]

	East Gippsland Region	Gippsland Region	North East Region	Total
Ash D+ (m^3)	6,880	154,739	209,444	371,063
Mixed species D+ (m^3)	613,923	37,777	11,937	663,637
Total sawlogs (m^3)	620,803	192,516	221,381	1,034,700

From this information, the greatest impact on standing timber volumes occurred in the East Gippsland RFA region, which had about 60% of the impacted timber. However, in terms of the impacts on the highly productive ash forests, 56% of the losses occurred in the North East RFA region and 42% occurred in the Gippsland RFA region.

In 2017, the Climate Council reported that the economic cost of bushfires in Victoria is expected to double by 2050, and fire severity, frequency, extent and duration are increasing.[1579] However, the economic, social and cultural impacts of bushfires vary depending on many factors, including the weather leading up to the fire season, the nature of the landscape where they burn, proximity to human settlements, and the actions taken by governments and the community prior to, during and after the bushfires.

The impacts of bushfires will also vary from one season to the next. The Victorian Government compiled a summary of historical bushfire impacts for six bushfire seasons in Victoria, which includes the number of lives lost, homes destroyed, and area burnt.[1580] Impact of bushfire on biodiversity is discussed within indicator 'Fi:03 Actual fire regimes compared to optimal fire regimes'.

1577. Department of Jobs, Precincts and Regions (DJPR) 2021, 'Harvest level in Victorian regional forest agreement regions', Melbourne, Victoria. https://djpr.vic.gov.au/__data/assets/pdf_file/0016/2051431/Harvest-Level-in-Victorian-RFA-regions_Final-Report.pdf Accessed 18 October 2022.
1578. Ibid.
1579. Hughes L, Alexander D 2017, 'Climate change and the Victoria bushfire threat: Update 2017', Climate Council of Australia, Sydney, New South Wales.
1580. Forest Fire Management Victoria, 'Past bushfires', Melbourne, Victoria, https://www.ffm.vic.gov.au/history-and-incidents/past-bushfires Accessed 26 April 2023.

Fire

Indicator Fi:03 Actual fire regimes compared to optimal fire regimes in public forests

Fi:03 Actual fire regimes compared to optimal fire regimes in public forests

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide (public forests)	🔴	↙	🟡	🟡	↙	🟢
Data source(s):	DELWP					
Measure(s):	TFI distribution on public forests between 2007 and 2021 Impact of 2019–20 bushfires on threatened species and communities					

Why this indicator?

Inappropriate fire regimes can cause disruption to sustainable ecosystems and result in a loss of biodiversity by changing the long-term structure of plant communities and the composition of fauna communities in public forests.

Why this assessment in 2023?

Many areas are now experiencing increased frequency of fires. The area of public forests below the minimum TFI is increasing and the area with a no-burn history is decreasing. The 2019–20 bushfires had a significant impact on TFI metrics, especially for the East Gippsland RFA region. This would suggest that the status is now 'poor'.

The trend is for an increasing area of public forests to be below the minimum TFI, while the area unburnt is decreasing, thus the deteriorating trend.

There is a high level of confidence in the data. TFI is a key measure of fire interval, which is an important component of ecosystem resilience for plant species. From 2023 onwards, DEECA aims to implement a new set of metrics to improve the ability to quantify and track additional fire regime components, including fire severity, time-since-fire, fire interval and spatial patterns for flora and fauna.

Summary of State of the Environment 2018 Report assessment

- The Victorian Government used TFI as a metric to determine the resilience condition of key fire-response species. An increase in area of lower than minimum TFI and ongoing reduction in long unburnt habitats between 2007 and 2017 was a threat to biodiversity.
- Timing of the occurrence of future large fires may determine if current TFI regimes are appropriate.

Critical data used for the 2023 assessment

- Impact of 2019-20 bushfires on TFI statewide and for East Gippsland RFA region
- Impact of 2019-20 bushfires on listed fauna species under the FFG Act

2023 assessment

DEECA's fuel management program considers how best to meet objectives specified in the Code of Practice for Bushfire Management on Public Land 2012 and recognises the need to manage these objectives over different temporal and geographic scales. This is achieved through managing fuels and conducting burns to protect, maintain and/or improve ecosystem values and to build ecosystem resilience.

To understand the effects of both natural and fuel management fires on the environment, DEECA measures and monitors the timing and number of fires in a range of vegetation types having different TFIs. DEECA also measures and monitors the ages of different types of vegetation using their GSS. DEECA is in the process of developing new metrics for ecosystem resilience which will aim to quantify the impacts of additional fire regime components.

Fire

As a result of the 2019–20 bushfires, around 10% of vegetation on public land (758,056 ha) across the state was burnt in 2019-20 while it was still below minimum TFI (Figure Fi5). This is by far the greatest extent burnt while the ecosystem was below minimum TFI since 1980. This means that such areas have an increased likelihood of the vegetation undergoing a long-term, and potentially irreversible, change in its composition and structure (e.g. alpine ash forest being replaced by acacia thickets).[1581] Furthermore, the extensive fires of the last decade mean that more than half of Victoria's native forests are now sitting below minimum TFI and, therefore, are vulnerable to similar irreversible changes if they are burnt again in the next 10 to 30 years. Considering future climate change scenarios, this trend is expected to intensify.[1582] Vegetation areas below the minimum TFI are likely to experience more frequent large and severe fires while still below the minimum TFI.

Vegetation GSS is used to indicate ecosystem resilience at a landscape level, as well as TFI. GSS is a mix of different age stages: juvenile, adolescent, mature and old. A vegetation's GSS depends on when it was last burnt or otherwise disturbed. Figure Fi6 shows changes in GSS for Victorian public land between 1997 and 2021 and demonstrates that, overall, vegetation on public land (~7.5 million ha) has aged. There has been a 18% increase in vegetation in the juvenile growth stage (1.3 million ha) and a 10% increase in the adolescent growth stage (779,500 ha), but a 7% decrease in the mature growth stage (~530,000 ha). Areas that have no fire history had decreased by approximately 1 million hectares within the same period. This potentially means that some areas experienced an ongoing reduction in long-unburnt habitats as they succumb to recent bushfires.

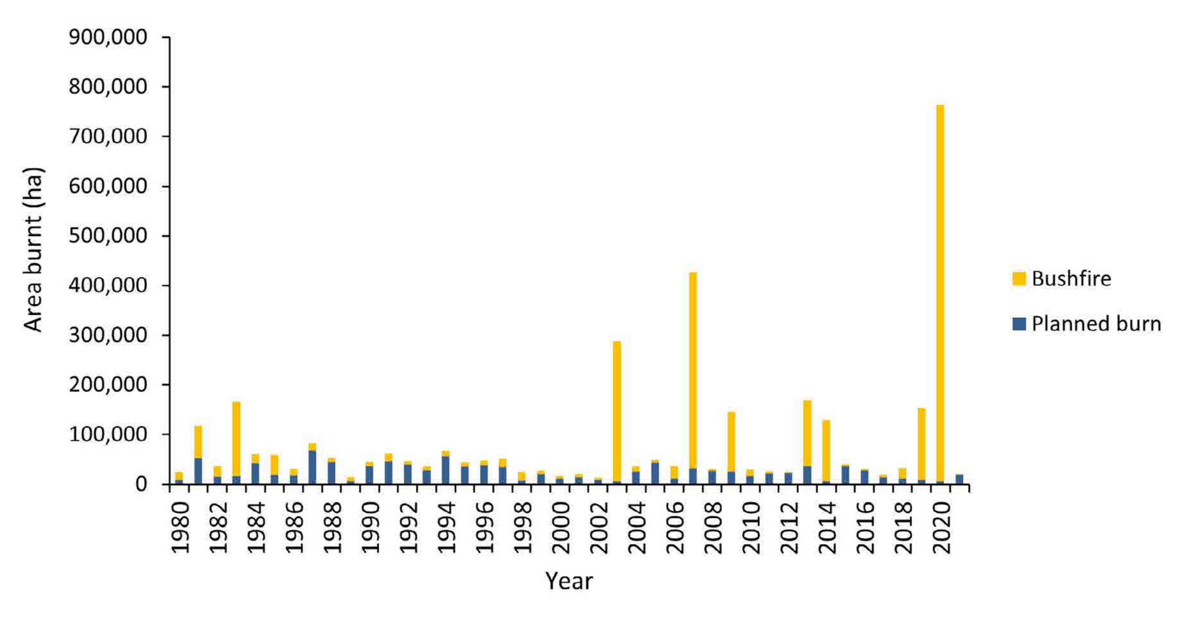

Figure Fi5: Area of public land burnt while below minimum TFI in Victoria from 1980 to 2021.[1583]

[1581] McColl-Gausden SC, Bennett L, Ababei DA, Clarke HG, Penman TD 2022, 'Future fire regimes increase risks to obligate-seeder forests', *Diversity and Distributions*, 28, pp. 542–558, https://doi.org/10.1111/ddi.13417 Accessed 28 October 2022.

[1582] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victoria's climate science report 2019', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0029/442964/Victorias-Climate-Science-Report-2019.pdf Accessed 18 October 2022.

[1583] Forest Fire Management Victoria 2023, 'Bushfire risk to life and property and ecological values', Melbourne, Victoria, https://www.ffm.vic.gov.au/fuel-management-report-2020-21/statewide-achievements/bushfire-risk Accessed 26 April 2023.

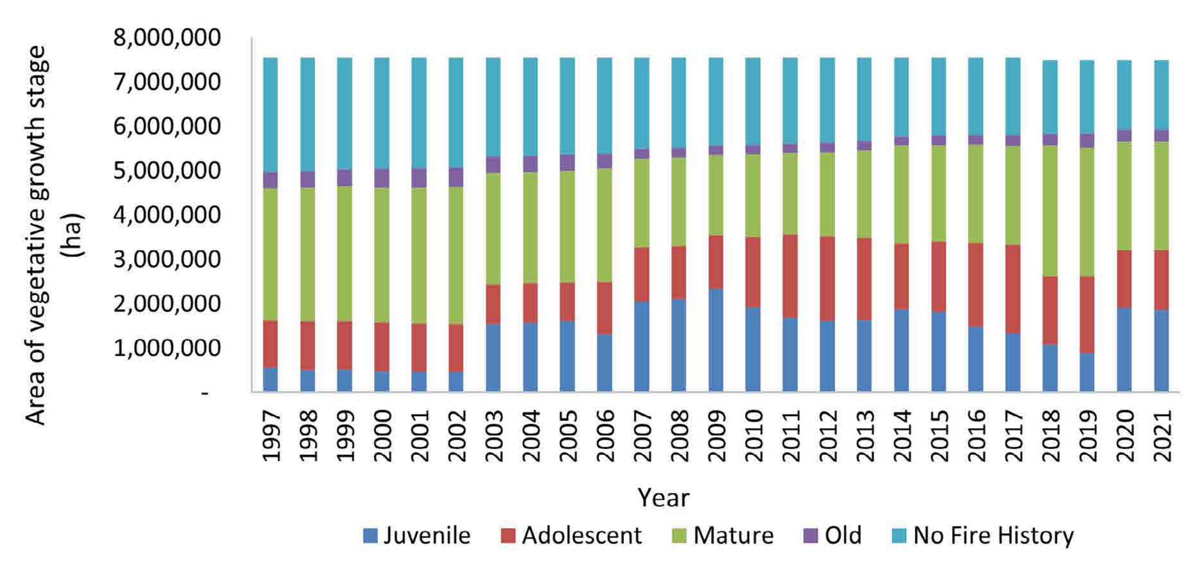

Figure Fi6: Area of vegetation growth stage on Victoria's public land from 1997 to 2021.[1584]

As the extent of the 2019-20 bushfires was concentrated on the eastern part of Victoria, the East Gippsland RFA region is at its worst TFI status in three decades. Figure Fi6 shows that in 2020-21:

- approximately 87% of the vegetation was below minimum TFI, a figure maintained from the previous year
- the proportion of vegetation within TFI was maintained at 9%
- less than 1% (<1,700 ha) of the vegetation remained above maximum TFI
- the proportion with no recorded fire history was maintained at 4%.

Having close to 90% of vegetation below the desired minimum TFI potentially puts East Gippsland RFA at a beyond-critical status. There has been a 35% increase in vegetation below minimum TFI as a result of the 2019–20 bushfires. TFI information does not account for the actual differences experienced in the severity of fire at different sites within a single forest ecosystem. This makes it difficult to interpret and understand the implications of this situation on the overall resilience of the different forest ecosystems within the RFA region. DEECA advised that this limitation will be addressed in the new suite of metrics to be implemented in 2023. Nevertheless, Figure Fi7 provides valuable information and demonstrates that the region's vegetation is currently in an unprecedented state of vulnerability to future fire.

Based on the research from the University of Melbourne, the Major Event Review Report found that, under emerging fire regimes with short-interval high-intensity wildfires, forests that are known to be the most fire-tolerant can be challenged to survive or potentially change their regeneration capacity and structure.[1585] Since 2000, there are around 276,000 hectares of public land within Victoria's RFA regions burnt more than twice, and almost 14,000 hectares of that 276,000 hectares has been burnt twice at high severity over the past 20 years. The report recommended that the Victorian Government commit to developing a comprehensive, long-term research and monitoring program to improve understanding of the impacts of repeated, short-interval severe bushfires on the long-term stability of forest ecosystems. Another research project also provided conceptual modelling results of impacts of shorter fire interval on fire-tolerant woody plants.[1586]

[1584] Ibid.

[1585] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires' https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf Accessed 21 November 2022.

[1586] Enright N, Fontaine JB, Bowman DMJS, Bradstock RA, Williams RJ 2015, 'Interval squeeze: altered fire regimes and demographic responses interact to threaten woody species persistence as climate changes', *Frontiers in Ecology and the Environment*, 13(5), pp. 265-272.

Fire

The model predicted that the altered fire interval will increase woody plant extinction risk and change ecosystem structure, composition and carbon storage. A study in southwest Australia also found that fire-tolerant resprouter forests (*Eucalyptus diversicolor*) found that mature karri tree *(Eucalyptus diversicolor*) mortality was 87% greater at sites burnt at high severity compared to unburnt sites and sites burnt at low severity.[1587]

The TFI definition is based on the concept of ecological resilience where systems have the capacity to absorb a particular type of disturbance within certain bounds of frequency, and intensity and retain their fundamental identity. TFI represents a fire interval range within which systems are expected to be resilient. However, when these thresholds are exceeded, ecosystems may shift to a different identity (composition, structure, function) from which returning to their original state may be difficult, or impossible. The threshold for different vegetation communities needs to be understood as vegetation communities will be confronted with climatic conditions that are different to historical records.

A rapidly changing climate with a growing number of extreme weather events means that current TFIs for many vegetation communities, especially obligate seeders, may need to be further researched. One research project in Western Australia indicated that declining rainfall during adolescent period is likely to markedly increase the minimum TFI, especially for serotinous non-sprouters.[1588]

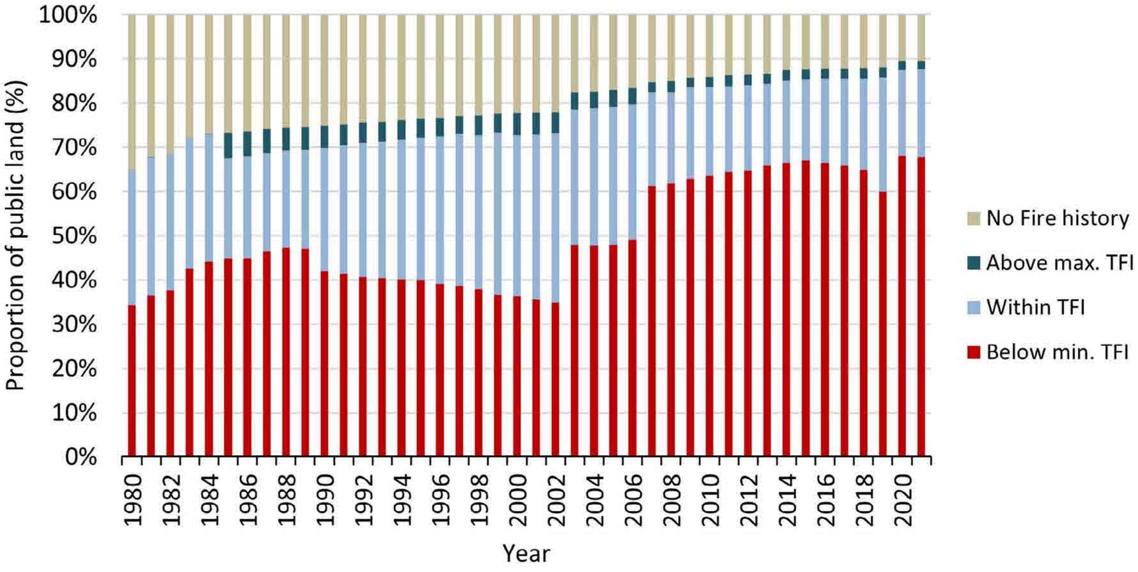

Figure Fi7: TFI status of vegetation on public land in the East Gippsland RFA from 1980 to 2021.[1589]

The 2020 Victorian Auditor-General's Office (VAGO) audit on reducing bushfire risks also covered the use of TFI and GSS by the then Department of Environment, Land, Water and Planning (DELWP). VAGO commented that both metrics do not report the results or outcomes that these assessments demonstrate, nor do they compare the status of the metrics with set thresholds that show desired states.

[1587] Etchellls H, O'Donnell AJ, McCaw WL, Grierson PF 2020, 'Fire severity impacts on tree mortality and post-fire recruitment in tall eucalypt forests of southwest Australia', *Forest Ecology and Management*, 459, pp. 117850.

[1588] Enright NJ, Fontaine JB, Lamont BB, Miller BP, Westcott VC 2014, 'Resistance and resilience to changing climate and fire regime depend on plant functional traits', *Journal of Ecology*, 102, pp. 1572-1581. https://doi.org/10.1111/1365-2745.12306 Accessed 26 April 2023.

[1589] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires' https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf Accessed 21 November 2022.

This makes it difficult to understand whether the reported mix of vegetation represents a high- or a low-level of ecosystem resilience.[1590] The Major Event Review Report recommended that the Victorian Government adopt the Geometric Mean Abundance metric, or a more suitable alternative measure, as an indicator of ecosystem resilience, as current measures are not sufficiently holistic to understand resilience against current and future fire regimes.[1591]

Many faunal species were heavily impacted by the 2019-20 bushfires. DEECA's Biodiversity Response and Recovery program assessed over 4,400 species and found that 244 species had at least 50% of their likely statewide habitat burnt, with 215 of these impacted species having a rare or threatened conservation status. The Major Event Review Report on the impact of 2019-20 bushfires found that there are six species that were exposed to high-severity fires across more than 50% of their overall extent: Betka bottlebrush *(Callistemon kenmorrisonii)*, roundsnout galaxias *(Galaxias terenasus)*, East Gippsland galaxias *(Galaxias aequipinnis)*, Mallacoota burrowing crayfish *(Engaeus mallacoota)*, Orbost spiny crayfish *(Euastacus diversus)* and eastern she-oak skink *(Cyclodomorphus michaeli)*. Another two listed species, the diamond *python (Morelia spilota spilota)* and the large brown tree frog *(Litoria littlejohni)*, have had at least 50% of their habitat impacted by multiple high-severity fires since 2000.[1592] The report also found that, for 51 of the 1,994 species listed under the FFG Act including 21 species listed as critically endangered, there are no data available within the biodiversity databases that would enable assessments to be undertaken to identify potential impacts associated with the 2019-20 bushfires.[1593] This suggests that the distribution of seven of these critically endangered species potentially occurs within the extent of the 2019-20 bushfires and would, therefore, benefit from an early effort to update distribution information and assess any impacts from these bushfires. These critically endangered species are:

- Wallagaraugh star-hair *(Astrotricha sp. 5)*
- Small hook-sedge *(Carex austrosulcata)*
- Shining coprosma x snow coprosma hybrid *(Coprosma x tadgellii)*
- Lobed veilwort *(Metzgeria saccata)*
- Limestone bristle-moss *(Orthotrichum cupulatum var. cupulatum)*
- Woodland woollywort *(Trichocolea rigida)*
- Black-beard lichen *(Usnea acromelana).*

Echnida after fire, Wilsons Promontory 2009.
© Parks Victoria.

[1590] Victorian Auditor-General's Office (VAGO) 2020, 'Reducing bushfire risks', Melbourne, Victoria. https://www.audit.vic.gov.au/sites/default/files/2020-10/20201014-Reducing-Bushfire-report_0.pdf? Accessed 16 March 2023.

[1591] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires' https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf Accessed 21 November 2022.

[1592] Ibid.

[1593] Ibid.

Indicator Fi:04 Bushfire risk

Fi:04 Bushfire risk

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	↙	🟢	🟡	↙	🔴
Data source(s):	DELWP					
Measure(s):	Residual bushfire risk and the role of planned burning Condition of risk to community Bushfire risk to biodiversity					

Why this indicator?

Changes in the bushfire risk within fire-affected areas and refugia will influence conservation efforts for threatened species and ecological communities, and also fire-fuel management processes.

Why this assessment in 2023?

Based on the potential thresholds for status, which rely on DEECA risk targets, the status remains as fair. However, the multiple metrics complicate the assessment of this indicator. Residual risk targets are largely achieved by planned burning. The targets are entirely based on risk to human life and property. There are currently no targets for ecosystem resilience. Furthermore, there is currently no definition of what a desirable ecosystem resilience target should be. VAGO's 2020 audit, Reducing Bushfire Risk, concluded that the impact on ecosystem resilience is not well monitored or reported. Planning regulations have not prevented settlements in fire-prone, peri-urban areas. Climate change is exacerbating fire weather and increasing bushfire risk.

A range of factors are influencing changes in bushfire risk, including changes to fire weather, which will increase fire frequency and severity. Thus, the trend is assessed as deteriorating. The trend in biodiversity responses is also assessed as deteriorating. However, movement towards meeting the residual risk targets would suggest an improving trend for one of the three measures.

There is sufficient information on the bushfire impact on communities and environment. The Victorian Government has been regularly updating how state and regions have been meeting their bushfire risk targets and what activities, such as planned burns, have been applied to manage the risk level.

Summary of State of the Environment 2018 Report assessment

- The impact of the risk-based planned-burning approach on biodiversity, particularly fauna species, was not monitored at a state-scale but isolated data existed.
- Statewide residual bushfire risk was below the target of 70%, but this target does not consider potential harm to Victorian ecosystems.
- Bushfire risk was expected to continually increase due to worsening climate change events, leading to increase in the frequency and magnitude of extreme conditions in some areas.

Critical data used for the 2023 assessment

- Residual bushfire risk targets and 2020-21 bushfire residual risk by fire management region
- Major Event Review Report
- Demographic distribution and bushfire risk
- Climate change impact on fires in forests

Fire

2023 assessment

Reduction of bushfire risk

DEECA and other agencies aim to reduce the state's bushfire risk to, or below, 70% of what it would be without risk-reduction activities. This is expressed as the number of houses that would be destroyed in extreme fire conditions. Detailed description of how the target is selected using Phoenix Rapidfire prediction program can be found in Section 2.3 of VAGO's report: Reducing Bushfire Risks.[1594] If a 70% target is achieved, then 30% of all of the houses that would have been lost had no fuel reduction had occurred would be saved. Table Fi4 lists the residual bushfire risk and the long-term residual risk targets for each of Victoria's fire management regions.

The aim of these targets is to reduce the risk that bushfires pose to life and property in Victoria through planned burning to 70% of what it would have been if no fuel reduction had been undertaken. As indicated in Fi:01 indicator, DEECA's modelling results on the relative contributions of planned burning and bushfires to reductions in bushfire risk indicate that most risk reduction has been achieved through planned burning, even when considering the influence of major bushfires including the 2009 Black Saturday fires and 2019-20 bushfires. However, further analysis needs to be conducted as indicated by the University of Melbourne.

Table Fi4: Residual risk targets and the long-term residual bushfire risk target by fire management region.[1595]

Region	Residual Bushfire Risk assessed in 2020-21 (%)	Long-Term Residual Bushfire Risk Target (%)
Statewide	63	70
Barwon South West	62	60
Gippsland	42	71
Grampians	75	70
Hume	69	69
Loddon Mallee	71	75
Greater Melbourne	85	85

Bushfire risk to community

The demographic distribution of Victoria's population also could potentially lead to a range of vulnerabilities to bushfire. Buxton (2020) observed:

> 'The 2019–20 fires demonstrated yet again that dispersed rural dwellings, farms and housing on the outskirts of towns are most vulnerable, and often undefendable. Yet extensive subdivision and dwelling construction continues in these areas. A noticeable feature of the fires was the number of small towns abandoned in whole or part by fire authorities and the entry of some fires into larger towns and even town centres' … and … 'The population of the 24 fastest-growing local government areas on the edges of Australia's major cities has risen to 4.5 million over the past decade, much of it in some of the world's most fire-prone areas. The existence of many thousands of small lots in vulnerable areas on the fringes of major cities and regional towns is a deadly time bomb, yet these developments proceed with little or no fire-danger oversight.' [1596]

[1594] Victorian Auditor-General's Office (VAGO) 2020, 'Reducing bushfire risks', Melbourne, Victoria. https://www.audit.vic.gov.au/sites/default/files/2020-10/20201014-Reducing-Bushfire-report_0.pdf? Accessed 16 March 2023.

[1595] Forest Fire Management Victoria 2023, 'Bushfire risk to life and property and ecological values', Melbourne, Victoria. https://www.ffm.vic.gov.au/fuel-management-report-2020-21/statewide-achievements/bushfire-risk Accessed 26 April 2023.

[1596] Buxton M 2020, 'Bushfires: Do we need homes among the gum trees?' The Australian 10 November 2020.

Changes to planning regulations were made after the 2009 Black Saturday fires to provide planners with more options to manage bushfire hazards in rural and peri-urban areas. However, the Victorian Auditor-General found its Reducing Bushfire Risk audit that the new regulations only apply to new developments and extensions to existing buildings, not to those built prior to the changes in planning regulations being implemented.[1597]

In developing bushfire risk reduction strategies, DEECA uses data about different values that are included in the objectives of the Code of Practice for Bushfire Management on Public Land as well as stakeholder expertise to understand the impact of bushfire for a range of values. The aim is to design fuel management strategies that consider the range of values in the landscape. DEECA works with local communities and stakeholders to test their preferences for the best mix of protections to these different values.

As a part of the strategic planning process, all values in the landscape that could be exposed to bushfire risk are considered. Residential property is one of the critical values in this risk assessment process. DEECA is implementing their strategy to improve its statewide bushfire risk modelling framework. One of these improvements is the extension of the modelling to include additional values beyond the life and ecosystem resilience, which are already being considered. For example, pilot metrics are under development that consider the impact of fuel management activities and bushfire on fire size, critical infrastructure, water quality, and agricultural values such as farms.

Incorporating bushfire risk to environment

In developing the strategic zoning systems used in bushfire management plans, DEECA uses the bushfire simulation technology Phoenix RapidFire to identify forest areas where fuel management treatments will result in the greatest reduction in risk to the loss of houses. It then assesses the environmental impacts of the different strategies and considers trade-offs to select the best-performing strategy for given objectives. DEECA's Fire Analysis Module for Ecological Values (FAME) tool is used to evaluate the impact of different fire management strategies on ecological objectives, including the relative abundance of a species.

The Major Event Review Report found that, while this tool enables predictions of risk reduction to environmental values from implementation of prescribed burning, DEECA does not currently undertake such analyses in a manner equivalent to the prediction of reduced risk to the loss of houses.[1598] The report also considers that history and the 2019–20 bushfires have also shown that there is a strategic need to manage fuels in the broader forest landscape to improve the likelihood of containing fires, or reducing their size and intensity, before they reach property or important ecological assets. The report found that there is a lack of clarity about how the zoning system covers ecological planned burns for the protection of assets such as old growth forests, fire-sensitive ecosystems, and threatened species and communities.

DEECA is currently in the process of responding to the Major Event Review. In response to the VAGO audit, DEECA is developing revised fuel management metrics and targets to be implemented in 2023. For ecosystem resilience, five new metrics will be implemented which will quantify the impacts of various fire regime components on ecosystem resilience. The modelling will be supported by a program of data improvements. A set of long-term outcome goals for ecosystem resilience will be complemented by short-term annual performance targets for fuel management activities in relation to ecosystem resilience which will enable progress toward the long-term objectives to be evaluated.

The 2019–20 bushfires have had a very significant impact on the extent of old growth forests in Eastern Victoria, with an estimated loss of 62,126 hectares of the modelled old growth extent. This represents an additional 15 decrease in Victoria's remaining old growth forests, which means that about 60 of Victoria's old growth forests have been lost since 2000, predominantly due to severe bushfires. However, there is no indication of how old growth forest will be protected through fuel

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[1597] Victorian Auditor-General's Office (VAGO) 2020, 'Reducing bushfire risks', Melbourne, Victoria. https://www.audit.vic.gov.au/report/reducing-bushfire-risks?section= Accessed 26 April 2023.

[1598] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires' https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf Accessed 21 November 2022.

management strategies and activities. As a result, the Major Event Review Report recommended that the Victorian Government implement strategies to inform and enhance the protection of remnant old growth forest from the impact of bushfires.[1599] The strategies should include implementing a mix of existing and innovative fire management practices that specifically focus on reducing bushfire risks to priority areas of old growth forest within each RFA region, in addition to other high value ecological areas and values.

Leading scientists from CSIRO and BoM indicated that climate change has driven a significant increase in Australia's forest fire activity over the last three decades.[1600] They found that, out of eight drivers of fire-activity that played varying roles in influencing forest fires, climate was the overwhelming factor driving fire activity. The increase in area of burnt forest is consistent with increasingly more dangerous fire weather conditions coupled with the association of pyro-convection, which includes fire-generated thunderstorms and increased ignitions from dry lightning. South-eastern Australia has a shortened frequency of forest megafires, resulting in some areas with fire intervals shorter than 20 years. This will cause a significant impact on some types of vegetation as they will not reach maturity, and this could put ecosystems at risk. Another academic research project also had consistent results, pointing to climatic conditions and fire weather as being highly influential factors in an increase in the size and severity of wildfires.[1601]

In response to the future climate change impact on our society and environment, the Victorian Government developed the Natural Environment Climate Change Adaptation Action Plan 2022-2026.[1602] The plan includes several actions specifically related to addressing future fire risk. These actions are related to:

- understanding the impact of a changing climate on fire regimes
- incorporating changing climate and associated uncertainty into decision-making for bushfire preparedness, response and recovery
- considering the climate adaptation lens in developing the Whole of Sector Bushfire Strategy and in renewal of the Victorian Waterway Management Strategy.

[1599] Major Event Review Independent Panel 2022, 'Victorian regional forest agreements: Major event review of the 2019-20 bushfires' https://www.agriculture.gov.au/sites/default/files/documents/vic-rfa-mer-bushfires-report-2022.pdf Accessed 21 November 2022.

[1600] Canadell JG, Meyer CP, Cook GD., Dowdy A, Briggs PR, Knauer J, Pepler A, Haverd V 2021, 'Multi-decadal increase of forest burned area in Australia is linked to climate change', *Nature Communication*, 12, pp. 6921, https://doi.org/10.1038/s41467-021-27225-4 Accessed 26 April 2023.

[1601] Collins L, Clarke H, Clarke MF, McColl Gausden, SC, Nolan RH, Penman T, Bradstock R 2022, 'Warmer and drier conditions have increased the potential for large and severe fire seasons across south-eastern Australia', *Global Ecology and Biogeography*, 31, pp. 1933–1948. https://doi.org/10.1111/geb.13514 Accessed 26 April 2023.

[1602] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Natural Environment Climate Change Adaptation Action Plan 2022-2026, Melbourne, Victoria, https://www.environment.vic.gov.au/data/assets/pdf_file/0030/558264/Natural-environment-Climate-Change-Adaptation-Action-Plan-2022.pdf Accessed 18 October 2022.

Burning tree at Wilson's Promontory National Park.
Credit: Art Laurenson. © Parks Victoria.

Caption: Lake Tyrrell Wildlife Reserve 2018.
Credit: Anne Morley. © Parks Victoria.

Commissioner
for Environmental
Sustainability
Victoria

Inland waters (IW)

Victorian State of the Environment 2023 Report

Water quality	**(WQ)**
Water resources	**(WR)**

Key findings

As Victoria's population grows, demand for water is increasing and climate change is placing more pressure on the availability of fresh water. Water quality is crucial for the wellbeing of people and the environmental health of flora and fauna.

Good-quality fresh water in rivers and streams is vital for the environment and culture, agriculture, human health and recreation. Water quality can be degraded in many ways, including by vegetation loss, pollution, catchment runoff and the impacts of climate change.

Victoria's Traditional Owners and Aboriginal Victorians managed water sustainably for thousands of years. The Victorian Government is working with Traditional Owners to strengthen their role in water planning and management; and Victoria's *Water Act 1989* now includes a provision to consider Aboriginal cultural values and uses of waterways, along with social and recreational uses and values, in the management of waterways.

These important changes come at a time when Victoria's water resources are under increasing pressure from climate change, population growth and competing demands. Over recent decades, Victoria has experienced less rainfall in the cooler months of the year when most rainfall occurs. This is expected to continue, and projected increases in summer rainfall are unlikely to offset this decline.

In this context, it is critical to appropriately balance the water allocations for consumption and the environment. Environmental water is water that is managed to improve or maintain the health of rivers, floodplains, wetlands and estuaries, and the plants and animals that depend on them.

Water quality

There are several differences in the status and trend assessments for the water-quality indicators in the 2018 and 2023 SoE reports (Table IW1). This is due to a number of factors:

- two wet years occurring between 2018 and 2021
- the 2019–20 bushfires
- the availability of new data from the Water Measurement Information System (WMIS), which was matched to the water-quality objectives of the Environment Reference Standard (ERS).

The WMIS contains real-time data delivered hourly for all telemetered surface-water gauges (including water level, flow, and water quality) and groundwater bores (for water level and water quality). As a result, water-quality data have improved significantly. The data are collected through Regional Water Monitoring Partnerships that include the Department of Energy, Environment and Climate Action (DEECA), Bureau of Meteorology (BOM), the Murray–Darling Basin Authority, Victorian water corporations, Victorian catchment management authorities (CMAs) and local councils.

The State of the Environment (SoE) 2018 Report used the objectives for the State Environment Protection Policy (Waters of Victoria), which was superseded by the ERS in 2021. Accordingly, for the 2018 SoE reporting period DELWP updated the water-quality data for the 2010-17 period assessed in the SoE 2018 Report to match the ERS water-quality objectives. this has enabled a comparison of the new data from the 2018-21 period with the data from the 2010-17 period.

Urban development and population growth, agricultural land management, irrigation and climate change are impacting on water quality and aquatic biodiversity in Victoria.

Indicator WQ:01 shows that blue–green algal blooms are becoming more frequent, of longer duration and spread over a larger area. However, data limitations prevent an assessment of status.

Indicators WQ:02 to WQ:07 comprise the physico-chemical indicators of water quality — dissolved oxygen, salinity, nitrogen, phosphorus, turbidity and pH — and they vary considerably across Victoria's CMA regions. Water quality is generally highest in the east of the state, where forest cover is largely intact, and then declines westwards as urban and agricultural development intensify.

Indicator WQ:08 assesses water quality across CMA regions using a combined score from indicators WQ:03 to WQ:07. In the SoE 2018 Report indicator WQ:08 was assessed on a statewide basis and was determined to be poor. In this SoE 2023 Report the assessment results are presented by CMA region, which shows that in some regions water quality has improved.

The quality of groundwater is still assessed as unknown in indicator WQ:09. So too are the assessments of status for indicators WQ:10 and WQ:11, which cover inland water pollution and the responses by EPA Victoria to pollution reports.

The SoE 2018 Report identified several critical challenges facing Victoria's management of water quality, which remain relevant five years later. They are:

- balancing the needs of catchment and waterway health with human and agricultural water consumption
- managing urban development and its impact on urban waterway health
- maintaining long-term water-quality monitoring data so that they are easily accessible and suitable for informing policy and strategy development
- mitigating against the following stressors:
  - increasing stormwater and wastewater discharges from urban areas
  - altered water regimes, salinity and algal blooms
  - an increase in catchment inflows from diffuse sources
  - localised events in which stressors on water quality, including nutrients, sediments, toxicants and pathogens, exceed objectives.

Water resources

The assessments for most water resources indicators are the same or similar in 2018 and 2023. One key difference is that 'WR:03 Surface water harvested for consumptive use' was rated as poor in 2018 and is now rated as fair in 2023.

Indicator 'WR:01 Water resources and storage trends' shows that since the SoE 2018 Report water storage levels have been variable, falling to below 40% of capacity in 2020 and rising to almost 100% in late 2022. While there has been a long-term decline in storage levels, recent levels are slightly higher than the average during the Millennium Drought from 1998 to 2010.[1603]

The long-term decline in inflows and storage levels, the projected growth of Victoria's population from 6.7 million to 11 million by 2056, and the anticipated impacts of climate change will increase pressure on the state's water resources.[1604] The use of groundwater and manufactured water (desalinated water, fit-for-purpose recycled wastewater and treated stormwater) is projected to increase, with one of the aims being to reduce reliance on river water and help stressed rivers recover.

Indicator WR:02 describes the important role that small farm dams play in rural communities. These dams provide water for stock, irrigation, gardens, domestic use and recreation. They provide habitat and refuges for frogs, waterbirds, invertebrates and reptiles, and can be used to support threatened species. However, farm dams also impact stream flows due to their interception of run-off, and can negatively impact aquatic life as well as downstream water consumers. Their number and storage volumes increased rapidly during the early stages of the Millennium Drought, but growth has now slowed. The limited monitoring of the smaller unlicensed farm dams limits analysis of the scale of their impacts.

Indicator WR:03 shows that waterway health is directly impacted by water diversion for human consumption. Reduced stream flows place stress on ecological functions and aquatic life in waterways. Many waterways across the state were rated poorly for hydrology in the Index of Stream Condition (ISC) released in 2013 and based on 2010 data, and the impacts of climate change on stream flows will make improvements difficult.

Indicator 'WR:04 Percentage of compliance with entitlements for the take of surface water' assesses compliance with water-extraction entitlements to support best-practice management of water resources and reduce impacts on aquatic ecosystems. Data for each of the 29 river basins shows that there has been compliance with bulk entitlements, with take below the available water resource. However, the setting of entitlement caps has not included a determination of an environmentally sustainable level of take.[1605]

[1603] Department of Energy, Environment and Climate Action (DEECA), 'Current water snapshot', https://www.water.vic.gov.au/water-reporting/water-snapshot Accessed 23 February 2023.

[1604] Department of Environment Land, Water and Planning (DELWP) 2019, 'Victoria in future 2019: population projections 2016 to 2056', Melbourne, Victoria, https://www.planning.vic.gov.au/land-use-and-population-research/victoria-in-future Accessed 8 June 2023.

[1605] The *Water Act 2007* (Cth) requires an environmentally sustainable level of take.

Inland waters

As climate change and population growth increase pressure on Victoria's water resources, greater use of recycled water (WR:05) and treated stormwater (where fit for purpose) will be needed to help address supply shortfalls. However, the percentage of wastewater being recycled has not increased over the past decade due to several factors, including uncertainty in demand. Rainfall levels influence the volume needed for irrigation (the predominant end use of recycled water). Appropriately treated recycled water can also be used to boost environmental flows.

Irrigation agriculture is the dominant user of surface water, groundwater and recycled water in Victoria. Efforts to improve irrigation efficiency are the focus of indicator WR:06. The Australian (2009–2019) and Victorian governments have been investing in the modernisation of irrigation districts to improve agricultural productivity and the efficiency of water use.[1606] The saved water could be used to expand the land area under irrigation or to supplement environmental flows. While data for on-farm irrigation improvements are limited, surveys indicate that irrigators are improving the efficiency of their water use and using the gains to increase the resilience of the irrigation enterprise during dry periods when water allocations are lower.

Groundwater levels and consumption vary considerably across the state, as illustrated by the assessment for indicator WR:07. While many groundwater levels are stable, some are rising and others — in northern Victoria and Gippsland — are declining. Rising levels could indicate sustainable groundwater use; however, they could also lead to increased saline discharges and dryland salinity. Declining levels could indicate unsustainable use. Groundwater levels are generally expected to decline in the longer term. Data on the outcomes of this long-term decline are limited, particularly relating to the impact on groundwater-dependent ecosystems such as wetlands.[1607]

The 'Water resources' sections in the 2018 and 2023 SoE reports highlights:

- the ongoing impacts of climate change, population growth and land-use change on water storages, stream flows, groundwate and consumptive uses of water resources
- the relatively low volume of recycled water as a percentage of wastewater produced
- the lack of consistent and statewide data on improvements in irrigation
- variations in groundwater conditions and levels across the state, with many stable, some declining and several rising
- concentrations of high groundwater use in the state's north and in Gippsland.

Water for the environment

Average annual delivery of water for the environment from 2016–17 to 2020–21 (WR:09) was 743,402 ML. This was up 21% from the previous 5-year period (2011–12 to 2015–16). The amount of carryover water also increased during the past five years, up by 24% in 2020–21 compared with 2015–16. This demonstrates that more water has been available and delivered for the environment during this state of the environment reporting period relative to the previous state of the environment reporting period. Water allocations are generally greater in wet years compared with dry years. Given that Victoria's total rainfall for this five-yearly state of the environment reporting period increased by only 2.5%, the 21% increase delivery of water for the environment, and the 24% increase in carryover, represent a likely relative improvement in water availability for the environment. This analysis is best interpreted as an indicative guide to water availability for the environment because, even though it has been averaged across a 5-year period, environmental water allocations, delivery and carryover fluctuate from year to year.

A robust assessment of environmental water allocations over a longer period was completed for southern Victorian river systems in 2020 as part of the Long-Term Water Resource Assessment (LTWRA) for Southern Victoria. That assessment found that long-term surface water availability across southern Victoria has declined by up to 21%. The decline in water availability has not always been shared equally, with the declines falling disproportionately on the environment in some basins. The assessment also found that a smaller proportion of available water is now set aside for the environment than

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[1606] Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'On-farm irrigation efficiency program', https://www.dcceew.gov.au/water/policy/programs/completed/ofiep Accessed 15 August 2022.

[1607] Department of Environment, Land, Water and Planning (DEWLP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

when the last sustainable water strategies were developed between 2006 and 2011. A LTWRA for northern Victoria has not been completed, however an assessment is planned to start in 2025 to align with the Murray-Darling Basin Plan review scheduled for 2026.

Each year the Victorian Environmental Water Holder (VEWH) sets seasonal watering objectives that seek to achieve the best environmental outcomes with its available environmental water holdings. Monitoring and reporting of environmental watering by the Victorian Government is intended to contribute to advancing localised management of environmental water for better environmental outcomes. However, there is currently a gap in the monitoring of environmental watering outcomes at a statewide scale that needs addressing to improve future reporting as required by Action 3.6 of Victoria's water plan, Water for Victoria.

The VEWH's annual reports show that between 63% and 70% of its planned watering actions have been fully achieved, and 87% to 92% have been fully or partially achieved for each of the past three years (2019–20 to 2021–22). In comparison, an analysis of river flow data for each of the five years from 2017–18 to 2021–22 determined that between 19% to 35% of environmental flow study recommendations were fully achieved across Victoria. A further 43% to 51% of flow study recommendations were partially achieved each year, with 22% to 33% of recommendations not achieved.

The data shows that the VEWH is generally fully achieving what it has planned with its potential watering actions each year. However, there remains a shortfall to fully achieve the scientifically recommended flow regimes. This highlights a gap between what Victorian river systems need from a hydrological perspective and what the VEWH can currently achieve from its environmental watering program.

For many catchments in Victoria, the runoff response to rainfall has declined this century, particularly during the Millennium Drought (WR:08). This means that many Victorian catchments have been getting less streamflow for a given amount of rainfall compared with past decades. Since streamflow has been below the long-term average most years this century, the status assessment for the condition of flow regimes indicator is poor, consistent with the status assessment for this indicator in the SoE 2018 Report.

Water for the environment is having a greater impact on fully achieving wetland watering requirements than it is on fully achieving optimum river flows. These results only include assessments for rivers and wetlands where environmental water is being delivered, which incorporates most of the regulated rivers in Victoria but only a small percentage of regulated wetlands. Higher achievement of recommended water regimes is likely occurring in wetlands because environmental watering targets many of Victoria's highest value wetlands. In some instances, dedicated environmental infrastructure (e.g. pumps) is deployed to deliver environmental water entitlements to priority and icons sites. In contrast, environmental watering of river systems is more heavily impacted by available volumes of held environmental entitlements, the natural seasonal conditions in any given water year, physical constraints within delivery systems (e.g. outlet valve capacities) and policy constraints (e.g. the obligation to avoid flooding towns and private land).

As per the *Water Act 1989*, water for the environment is delivered for the purpose of preserving the environmental values and health of water ecosystems, including:

- their biodiversity
- ecological functioning
- the quality of water
- the other uses that depend on environmental condition.

Current monitoring and reporting of environmental watering by the Victorian Government is intended to improve the use of environmental water at a given time in a particular location. This contributes to better localised management of environmental water. However, there is a knowledge gap, with no quantitative analysis of environmental watering outcomes available (both environmental and community outcomes) to be produced on a statewide scale.

Table IW1: Inland waters indicators assessed in this chapter with comparisons to SoE 2018 assessments.

Inland waters — Water quality

2023 Indicator	2023 status	2023 trend	2023 confidence
WQ:01 Occurrence of algal blooms	🟡	↙	🟡
WQ:02 Dissolved oxygen concentrations in rivers	🟢 (All CMAs)	→	🟢
WQ:03 Salinity concentrations in rivers	🟢 (7 CMAs) 🟡 (2 CMAs) 🔴 (1 CMA)	→	🟢
WQ:04 Total nitrogen concentrations in rivers	🟢 (3-4 CMAs)[a] 🟡 (3 CMAs) 🔴 (3-2 CMAs)[a] ⚪ (Mallee CMA)	↗	🟢
WQ:05 Total phosphorus concentrations in rivers	🟢 (2-4 CMAs)[a] 🟡 (4 CMAs) 🔴 (3-1 CMAs)[a] ⚪ (Mallee CMA)	↗	🟢

2018 Indicator	2018 status	2018 trend	2018 data quality
WQ:01 Occurrence of algal blooms	🟡	?	🟡
WQ:02 Dissolved oxygen concentrations in rivers	🟢 (All CMAs)	→	🟢
WQ:03 Salinity concentrations in rivers	🟢 (7 CMAs) 🟡 (2 CMAs) 🔴 (1 CMA)	→	🟢
WQ:04 Total nitrogen concentrations in rivers	🟢 (2 CMAs) 🟡 (2 CMAs) 🔴 (5 CMAs) ⚪ (Mallee CMA)	→	🟢
WQ:05 Total phosphorus concentrations in rivers	🟢 (1 CMA) 🟡 (2 CMAs) 🔴 (6 CMAs) ⚪ (Mallee CMA)	→	🟢

Inland waters — Water quality

2023 Indicator	2023 status	2023 trend	2023 confidence		2018 Indicator	2018 status	2018 trend	2018 data quality
WQ:06 Turbidity levels in rivers	🟢 (5-10 CMAs)[a] 🟡 (5-0 CMAs)[a]	↗	🟢		WQ:06 Turbidity levels in rivers	🟡 (3 CMAs) 🔴 (7 CMAs)	↙	🟢
WQ:07 pH levels in rivers	🟢 (10-7 CMAs)[a] 🟡 (0-2 CMAs)[a] 🔴 (1 CMA)	↙	🟢		WQ:07 pH	🟢	→	🟢
WQ:08 Proportion of water bodies with good ambient water quality	🟢 (2-1 CMAs)[a] 🟡 (3-8 CMAs)[a] 🔴 (4-0 CMAs)[a] ⚪ (1 CMA)	↗	🟢		WQ:08 Proportion of bodies of water with good ambient water quality	🔴	↙	🟢
WQ:09 Groundwater quality	⚪	?	⚪		WR:11 Groundwater quality	🟢 (eastern Victoria) 🔴 (north-western Victoria) 🟡 (elsewhere)	→	🟡

Inland waters — Water quality

2023 Indicator	2023 status	2023 trend	2023 confidence	2018 Indicator	2018 status	2018 trend	2018 data quality
WQ:10 Volume of treated and poorly treated discharges to surface waters and compliance with licence requirements	●	?	●	WQ:09 Volume of sewage discharge to surface waters	●	?	🔴
WQ:11 Percentage of inland water pollution reports requiring a field response by EPA Victoria	●	?	●	WQ:10 Reported inland water pollution incidents	NC[b]	NC[b]	NC[b]

Inland waters — Water resources

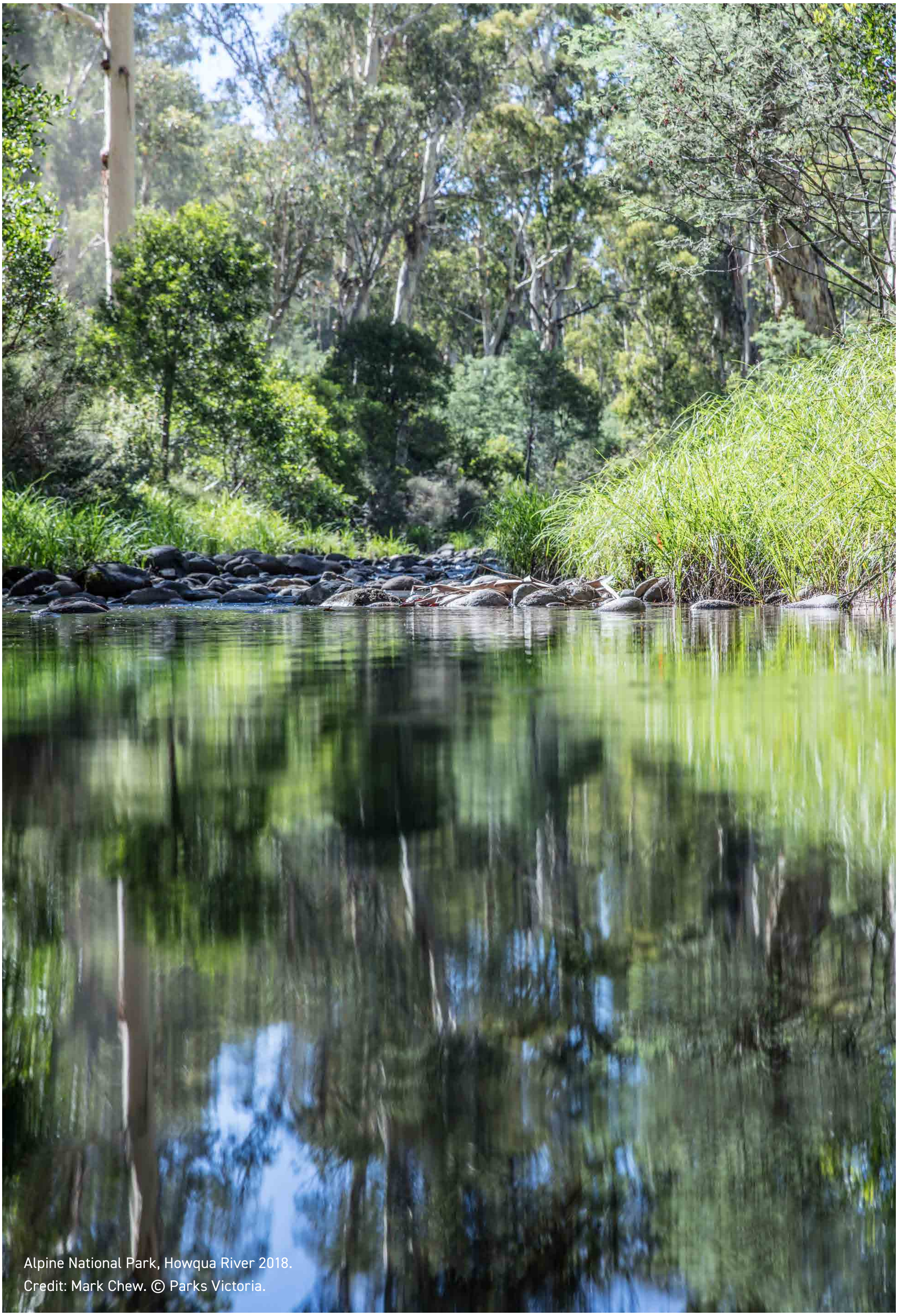
2023 Indicator	2023 status	2023 trend	2023 confidence	2018 Indicator	2018 status	2018 trend	2018 data quality
WR:01 Water resources and storage trends	🟡	↙ (long term) ↗ (short term)	🟢	WR:01 Water resources and storage trends	🟡	→	🟢
WR:02 Interception of surface water by small farm dams	🟡 (southern rivers) ● (northern rivers)	↙	🟡	WR:05 Number of dams, weirs and levees	🟡	?	🟡
WR:03 Surface water harvested for consumptive use	🟡	↙	🟢	WR:06 Surface water harvested for consumptive use	🔴	→	🟢
WR:04 Percentage of compliance with entitlements for the take of surface water	🟢	→	🟢	WR:07 Percentage of waterways and groundwater areas subject to extraction, with a limit on extraction	🟢	→	🟢

Inland waters — Water resources

2023 Indicator	2023 status	2023 trend	2023 confidence	2018 Indicator	2018 status	2018 trend	2018 data quality
WR:05 Water recycling	🟡	↙	🟢	WR:08 Water recycling	🟡	↗	🟢
WR:06 Percentage of agricultural land with improved irrigation	⚪	↗	⚪	WR:09 Percentage of agricultural land with improved irrigation	⚪	?	🔴
WR:07 Groundwater levels, consumption and use	🟡	→ (most shallow aquifers) ↙ (shallow aquifers in northern Region; lower aquifers in Gippsland and northern Region)	🟢	WR:13 Groundwater harvested for consumptive use	🟡	→	🟢
WR:08 Condition of flow regimes	🔴	→	🟢	WR:03 Condition of flow regimes	🔴	↙	🟢
WR:09 Delivering water for the environment	🟡	→	🟡	WR:04 Delivering water for the environment	🟡	→	🟢

[a] *The first figure presented in brackets refers to the number of CMAs whose status was based on 2010 to 2017 data and the second figure presented in brackets refers to the number of CMAs based on 2018 to 2021 data*

[b] *NC indicates that comparisons between the SoE 2018 and SoE 2023 assessments for the modified SoE 2023 indicator is inappropriate due to the extensive level of variability in the measures and/or data used in the assessment between SoE reports.*



Alpine National Park, Howqua River 2018.
Credit: Mark Chew. © Parks Victoria.

Victorian Government progress on State of the Environment 2018 Report recommendations

The SoE 2018 Report included recommendations to the Victorian Government to improve environmental sustainability outcomes. Presented below are the recommendations specific to this theme as well as:

- the full government response to the recommendations, including the level of support, as published in the Victorian Government Response to the State of the Environment 2018 Report
- a description of progress made on the implementation of the recommendation over the past five years. No information was provided by Government in relation to the progress on this recommendation. Instead, the content of this section is derived from the synthesis of information that is publicly available in referenced reports, legislation and websites. Importantly, this section summarises the progress made since 2018 in relation to the recommendation; it is not an audit of the extent and quality of the completed work.

Water quality

Recommendation 12 of the SoE 2018 Report recommended:

> *That DELWP, working with its portfolio agencies, implement an agile water-quality monitoring framework that (i) clarifies the roles and responsibilities of all agencies and the community, (ii) improves monitoring of pollution hotspots, and (iii) builds on EPA Victoria's implementation of EPA Inquiry Recommendations 6.3 and 7.2.*

Government response in 2020:

SUPPORT

'The Victorian Government supports this recommendation. The Department of Environment, Land, Water and Planning (DELWP) has established a water quality steering committee. Its role is to:

- Provide strategic oversight of water quality policy issues, water quality monitoring and research.
- Improve communication between DELWP teams with responsibility for water quality.
- Provide strategic direction for water quality incident management responsibilities.'[1608]

'DELWP will work with its portfolio partners to extend the existing water quality monitoring framework to be more agile so that it can incorporate and report on water quality hotspots. Roles and responsibilities of the partners will be more clearly articulated.' [1609]

'DELWP manages and co-ordinates the Regional Water Monitoring Partnership (RWMP) which is responsible for an extensive state-wide network of water quality monitoring sites. The RWMP is made up of 45 different agencies (water corporations, CMAs, Bureau of Meteorology, Murray Darling Basin Authority, DELWP and local government). As well as the fixed network of site monitoring stations, RWMP partners can deploy what is known as portable automated loggers at short notice to monitor water quality events. An increasing number of water quality sites now have telemetered real time data.' [1610]

'The RWMP has formed a water quality working group that will take the lead on addressing Partnership water quality issues, investigate and make recommendations on new water quality technology.' [1611]

'DELWP strongly supports the catchment management authorities carrying out citizen science programs such as Waterwatch and EstuaryWatch which supplement the state-wide monitoring network by providing information on local water quality issues.' [1612]

'DELWP will continue to work with stakeholders to identify practical opportunities to better coordinate environmental management activities with monitoring and reporting to:

[1608] Department of Environment Land, Water and Planning (DELWP) 2020, 'Victorian Government response to the state of the environment 2018 report', Melbourne, Victoria.

[1609] Ibid.

[1610] Ibid.

[1611] Ibid.

[1612] Ibid.

- Improve natural resource management decision-making.
- Provide information to communities and stakeholders.
- Achieve environmental and public health outcomes.' [1613]

'DELWP has identified that improved data sharing, and more accessible public environmental information are required.' [1614]

'Recommendation 6.3 from the Independent Inquiry into the Environment Protection Authority (EPA) required the EPA [Victoria] to assess the adequacy of its air and water monitoring networks, particularly in relation to air quality, and consider options to improve data sharing and accessibility, and community communications. The EPA [Victoria] has fulfilled Recommendation 6.3 through the delivery of the report and evaluation of EPA [Victoria]'s environmental monitoring and assessment programs. EPA [Victoria] will develop implementation plans and monitoring and assessment frameworks relating to its monitoring networks in line with the intent of the Recommendation 6.3 assessment over time and as funding becomes available.' [1615]

'Recommendation 7.2 from the EPA Inquiry required DELWP to implement measures to coordinate environmental management in Victoria, in partnership with the EPA [Victoria] and other agencies responsible for environmental, public health and other liveability outcomes, including state-wide environmental monitoring, a state-wide spatial data system and state reporting of health, environmental and liveability outcomes. DELWP is identifying practical opportunities to better coordinate environmental management, improve monitoring and reporting to support decision-making and public health outcomes, and share information with communities and stakeholders on environmental and public health outcomes.' [1616]

Progress made since 2018

No information was provided by Government in relation to the progress on this recommendation.

However, it is noted that there has been some progress made in the development of legislation, policies and strategies that could support the implementation of the SoE 2018 Recommendation 9, including a new Environment Protection Act, the release of the Environment Reference Standard, EPA Victoria's Strategic Plan 2022-2027, Melbourne Water's Healthy Waterways Strategy 2018-2028, the Central and Gippsland Region Sustainable Water Strategy, the Yarra Strategic Plan 2022-32, and urban water strategies. However, progress towards an agile water quality framework and monitoring of pollution hotspots has been limited.

Water resources

Recommendation 11 of the SoE 2018 Report recommended:

> *That DELWP use the current LTWRA to identify metrics for monitoring the condition of, and risks to, Victoria's water resources and waterway health for reasons related to flow, and commit to long-term monitoring. Complementary thresholds would also be established for these metrics, and actions determined for circumstances when thresholds are crossed. Further, in a changing climate, it is recommended that DELWP review the 15-year periods between LTWRAs, as more frequent assessments may be required to maintain ecosystem health and function.*

Government response in 2020:

SUPPORT IN PRINCIPLE

[1613] Department of Environment Land, Water and Planning (DELWP) 2020, 'Victorian Government response to the state of the environment 2018 report', Melbourne, Victoria.

[1614] Ibid.

[1615] Ibid.

[1616] Ibid.

'The Victorian Government is committed to reviewing and improving waterway and catchment monitoring through Water for Victoria and using it to inform decision-making and action in waterway and catchment health. There are more appropriate mechanisms to achieving this recommendation than using the LTWRA and existing processes are in place to address these concerns as outlined below.' [1617]

'Under the *Water Act 1989 (Vic)*, the LTWRA is a retrospective technical assessment whereas Sustainable Water Strategies consider future risks to water resources and waterway health and are reviewed every five years. Expanding the scope of current LTWRA to include work on metric identification, data gaps and recommendations would stretch resources and compromise the quality of both the current LTWRA and potential recommendations for long-term monitoring. The Water and Catchment Legislation Amendment Act 2019 now provides for the findings of a LTWRA to be addressed through the preparation of a new, or review of an existing, Sustainable Water Strategy.' 1618

'The Government is undertaking a range of actions to respond to the challenge that climate change poses for water resources. These include investing in climate and hydrology research through the Victorian Water and Climate Initiative (VicWaCI) and building this knowledge into water resource planning decisions including through Sustainable Water Strategies and Urban Water Strategies. A range of other actions are documented in the Pilot Water Sector Climate Change Adaptation Action Plan. The Department of Environment, Land, Water and Planning (DELWP) is also currently gaining better information through monitoring programs like the Victorian Environmental Flows Monitoring and Assessment Program and Wetlands Monitoring and Assessment Program that can be used in the medium term (~5 years onwards) to set targets (measurable biological responses) for environmental water.' [1619]

Progress made since 2018

No information was provided by Government in relation to the progress on this recommendation.

However, it is noted that planning by DEECA for the development of a comprehensive monitoring program to support future Long Term Water Resource Assessment is currently underway. A key component of this planning is the examination of current and alternative metrics for monitoring the condition of, and risks to, waterway health for reasons related to flow. The establishment of thresholds for these metrics will be investigated as part of the planning process.

1617. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian Government response to the state of the environment 2018 report', Melbourne, Victoria.
1618. Ibid.
1619. Ibid.

Inland waters

Background

This chapter focuses exclusively on inland water systems. Marine and coastal environments are reported within the Victorian State of the Marine and Coastal Environment Report, a five-yearly report required under the Victorian *Marine and Coastal Act 2018.*

Water quality

Good quality fresh water in rivers and streams is vital for the environment as well as culture, agriculture, human health and recreation.[1620] However, there are many ways in which water quality can be degraded. The loss of vegetation cover in what is Australia's most cleared state has led to erosion, increased runoff, sedimentation of waterways and rising salinity levels. Other causes of a decline in water quality include:

- water pollution by waste, sewage an septic tank discharges
- fertiliser and pesticide runoff from agricultural land
- droughts, floods and bushfires
- nutrients, sediments, oil, metals and litter in stormwater runoff from urbanised areas
- cold-water pollution downstream of dams and hot-water discharges from power stations.

As Victoria's population grows, the demand for water is increasing and climate change is placing even further pressure on the quantity of fresh water. However, the quality of water will also become crucial for the future wellbeing of Victorians and aquatic life.

The SoE 2018 Report used the objectives for the SEPP (Waters of Victoria). Between 2014 and 2018, SEPP (Waters of Victoria) and SEPP (Groundwaters of Victoria) underwent a holistic scientific review conducted by EPA Victoria and overseen by a Science Advisory Panel. This included a review of the segments (areas with common environmental conditions), beneficial uses, and environmental quality indicators and objectives. Environmental quality indicators and objectives were changed to recognise new science and an improved understanding of the aspects of environmental quality that matter for different beneficial uses. They were developed in line with, and to complement, the nationally agreed approach outlined in the Australian and New Zealand Water Quality Guidelines. They had the benefit of being developed from improved long-term water quality monitoring data encompassing the variation in water quality that comes from droughts and floods.

Water quality objectives for surface waters were mostly locally derived to better represent Victorian conditions. Most of the derived objectives are designed to protect the environmental value of water-dependent ecosystems and species, as it is assumed that, if this environmental value is protected, then the other environmental values are also protected. Specific objectives were also developed for aquaculture and water-based recreation.

As the development and enactment of SEPP (Waters) was being finalised, and which would replace SEPP (Waters of Victoria), the review of Victoria's Environment Protection framework was underway. This review included the role of SEPP documents. In 2021, the new *Environment Protection Act 2017* (EP Act) was enacted. Water quality objectives became part of the ERS. In that same year, SEPPs were superseded by the ERS, which is a tool in the *EP Act.* The ERS covers ambient air, ambient sound, land and water (surface water and groundwater) and identifies environmental values that the Victorian community want to achieve and maintain. It also provides a way to assess those environmental values in locations across Victoria. Most of the values are accompanied by indicators and objectives to assess whether that value is being met.

The ERS is not, however, a compliance standard. Its purpose is to provide a benchmark for the assessment and reporting on the condition of Victoria's environment. Decision makers are expected to use the ERS when assessing proposals or activities, for example, licence applications to EPA Victoria, planning permits and environmental audits.[1621] Using data from the WMIS that has been interpreted and supplied by DELWP, this theme compares water quality data for CMA regions with the water quality objectives of the ERS.

[1620] Water quality in estuarine and marine segments have been covered in the State of the Marine and Coastal Environment 2021 Report.

[1621] Environment Protection Authority (EPA) Victoria, 'The environment reference standard', Melbourne, Victoria, https://www.epa.vic.gov.au/about-epa/laws/epa-tools-and-powers/environment-reference-standard Accessed 27 July 2021

Inland waters

Table WQ2 lists the ERS environmental values to be achieved or maintained for rivers and streams across the six geographical segments: Highlands, Uplands A, Uplands B, Central Foothills and Coastal Plains, Urban, and Murray and Western Plains.[1622, 1623]
For example, water dependent ecosystems and species are largely in the Highlands, Uplands A and Uplands B segments, whereas they are highly modified in the Urban segment. Traditional Owner cultural values is a value across all segments, as are water-based recreation, agriculture and irrigation.

Table WQ2: Environmental values of rivers and streams.[1624]

Environmental value	Highlands	Uplands A	Uplands B	Central Foothills and Coastal Plains	Urban	Murray and Western Plains
Water-dependent ecosystems and species	Largely unmodified	Largely unmodified	Largely unmodified	Slightly to moderately modified	Highly modified	Slightly to moderately modified
Human consumption after appropriate treatment	'Yes' if water is sourced for supply in a special water supply catchment area set out in Schedule 5 of the *Catchment and Land Protection Act 1994* or in accordance with the *Safe Drinking Water Act 2003.*					
Agriculture and irrigation	Yes	Yes	Yes	Yes	Yes	Yes
Human consumption of aquatic foods	Yes	Yes	Yes	Yes	Yes	Yes
Aquaculture	' Yes' if the environmental quality is suitable and an aquaculture licence has been approved in accordance with the *Fisheries Act 1995*					
Industrial and commercial use	-	Yes	Yes	Yes	Yes	Yes
Water-based recreation (primary contact)	Yes	Yes	Yes	Yes	Yes	Yes
Water-based recreation (secondary contact)	Yes	Yes	Yes	Yes	Yes	Yes
Water-based recreation (aesthetic enjoyment)	Yes	Yes	Yes	Yes	Yes	Yes
Traditional Owner cultural values	Yes	Yes	Yes	Yes	Yes	Yes

For each segment, the ERS specifies water quality indicators and the objectives ‘to be used to measure, determine or assess whether those environmental values are being achieved, maintained or threatened.’[1625] These have been used in the data supplied by DELWP for the assessment of indicators WQ:02 to WQ:08, which reviews the water quality in Victoria’s rivers and streams against the objectives of the ERS.

The ERS objectives vary across the segments and reflect local conditions, such as degree of naturalness, level of modification, general land use and the ‘expected water quality’. For example, the objective for salinity in the Highlands segment is ≤30 microseimens per centimetre (μS/cm), whereas for the Urban-segment tributaries of the Werribee and Maribyrnong rivers it is ≤3,000 μS/cm. In the case of turbidity, the same two segments have objectives of ≤3 nephelometric turbidity units (NTU) and ≤30 NTU, respectively. Where the ERS water quality objective is attained, it is deemed to represent good water-quality conditions. However, if the objectives are not attained, that potentially represents poor water quality.

1622. There are also environmental values listed for wetlands, estuarine and marine types of waters. These are not covered in this theme, which focusses on water quality in rivers and streams.
1623. The full set of ERS environmental values, indicators and objectives for rivers and streams in the six segments can be found at https://www.epa.vic.gov.au/about-epa/laws/compliance-and-directions/environment-reference-standard.
1624. Governor in Council 2021, 'Environment reference standard', Victoria Government Gazette, No. S 245, 26 May 2021.
1625. Environment Protection Authority (EPA) Victoria, 'The environment reference standard', Melbourne, Victoria, https://www.epa.vic.gov.au/about-epa/laws/epa-tools-and-powers/environment-reference-standard Accessed 27 July 2021

WQ:08 is in part an assessment of Victoria's water quality against Target 6.3 of the United Nations Sustainable Development Goal (UN SDG) 6, which is to ensure access to water and sanitation. Target 6.3 is:

> 'By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.' [1626]

The reporting period of this theme covers the years 2018 to 2021 and compares the results with those for 2010 to 2017. The years 2018 and 2019 were dry, followed by the wet years of 2020 and 2021 (and also 2022 for which water quality data were unavailable for this report). The physico-chemical parameters can vary depending on the weather patterns in a particular year. A dry year could lead to reduced levels of dissolved oxygen but also improved water clarity (turbidity) because of less runoff and sedimentation. By contrast, a wet year can produce the opposite effects for dissolved oxygen and turbidity.

Water quality and the 2019-20 bushfires

North-east Victoria and East Gippsland were hard hit by the 2019-20 bushfires and were where the CMAs observed significant reductions in waterway condition as a result. DELWP's biodiversity response and recovery report in 2020 revealed that:

> 'Native freshwater fish such as Victoria's highly range-restricted galaxiid species, are highly sensitive to the impact fires can have on immediate reductions of dissolved oxygen and water quality in streams due to debris flow moving down waterways after rain events. This has resulted in fish death events in some areas for example in the Cudgewa and Corryong Creeks and Tambo River.' [1627]

The bushfires burned though 53% of the East Gippsland catchment and 22% of the North East catchment.1628 Catchment and riparian vegetation were destroyed followed by rains which washed large volumes of sediment to waterways — the Tambo River and others were 'reduced to sludge.'[1629] Equipment at some water monitoring stations was also destroyed.[1630]

The Victorian Government has funded works to restore vegetation and re-establish water monitoring equipment.[1631] It also supported the replacement of burnt-out septic tank systems to prevent waterway pollution from failed domestic wastewater management in fire-affected areas.[1632] DELWP commissioned a report on the impacts of the 2019-20 bushfires on water quality in the seven river basins in north-east Victoria and Gippsland.[1633]

Key messages from the draft report are:

- About two thirds of sites (36 to 38 of 59 sites) where water quality data are collected in North-East Victoria and Gippsland had poor water quality following the Black Summer fires.
- Some sites were badly impacted. For example, the amount of sediment moving in the Murray River upstream of Lake Hume is now about 10 times greater than prior to the fires.
- While water quality in some sites has improved, mostly in the uplands, there are sites in both Gippsland and the North-East where poor water quality following rainfall events are likely to occur into the future.

1626. United Nations (UN), ' Progress on wastewater treatment (SDG target 6.3)', https://sdg6data.org/en/indicator/6.3.1 Accessed on 22 June 2023.
1627. Department of Environment Land, Water and Planning (DELWP) 2020, 'Victoria's bushfire emergency: Biodiversity response and recovery, Version 2', East Melbourne, Victoria.
1628. Department of Environment Land, Water and Planning (DELWP), 'Bushfire relief and recovery' https://www.communitybushfireconnection.com.au/recovery-theme-overview/ Accessed 26 September 2022.
1629. McNaughton J 2020, 'Bushfire debris turns Gippsland's Tambo River to sludge, suffocating eels', *ABC Gippsland*, 23 January 2020.
1630. Department of Environment Land, Water and Planning (DELWP), 'Bushfire relief and recovery' https://www.communitybushfireconnection.com.au/recovery-theme-overview/ Accessed 26 September 2022.
1631. Ibid.
1632. Ibid.
1633. Baldwin D 2022, 'Impacts of the 2019/2020 Black Summer bushfires on water quality in north-east Victoria and Gippsland', a draft report to the Department of Environment, Land, Water and Planning (DELWP).

- Not all sites where water quality data are collected had evidence of poor water quality following the fires. In some cases, fire didn't occur in their catchment, but in many cases, it was because the sites were downstream of dams. The dams intercepted some of the sediments and helped dilute the dissolved constituents.[1634]

The draft report also included data on the impacts on some of the indicators in this theme:

- Turbidity: highest levels on record at many monitoring sites after the fires
- Total Nitrogen: high in the Snowy River catchment, but less of an issue elsewhere
- Total phosphorus: 13 of the 59 sites recorded the highest or near highest levels on record
- Dissolved Oxygen: dropped to very low levels at several sites
- Salinity: patchy results with no substantive impacts.[1635]

Water resources

> 'Water is alive. Water is our life. Water sustains and creates, water has spirit. Water is central to our culture, identity, and cultural economies. Water is the lifeblood of Country.' [1636]

Victoria's Traditional Owners and Aboriginal Victorians managed water sustainably for thousands of years. With European colonisation, land and water rights were granted to settlers to the exclusion of Traditional Owners. These government actions were taken without regard to Traditional Owners or the deep significance that water holds for them.

The Victorian Government is now working with Traditional Owners to strengthen their role in water planning and management through the inclusion of Aboriginal values and traditional ecological knowledge, appointments to the boards of rural water corporations and catchment management authorities (CMAs), and the return of water to Country for culture, access and economic development. This is supported by amendments to the *Water Act 1989 (Vic)* that now includes the purpose of considering 'Aboriginal cultural values and uses of waterways, along with social and recreational uses and values, in the management of waterways.'

These are important changes and come at a time when Victoria's water resources are under increasing pressure from climate change, population growth and competing demands. Although 2020, 2021 and 2022 were wet years, and the levels of the state's major water storages rose in response, water is expected to become increasingly scarce due to the long-term drying trends associated with climate change. Over recent decades, Victoria has experienced reduced rainfall in the cooler months of the year, the time when most rainfall occurs in the state. This is expected to continue, while the projected increases in summer rainfall are unlikely to offset the decline. The reduction in cool-season rainfall has a disproportionate impact on water availability — the cooler months are when a larger proportion of rainfall becomes runoff.

An analysis for the Victorian Climate Initiative found that annual stream flows had declined by from 25% to 75% when 1997 to 2014 data were compared to data from the period of 1975 to 1997.[1637] There could be significant and widespread reductions in runoff, with the greatest reductions in south-western Victoria.

The 2020 LTWRA across southern Victoria's 18 river basins found that:

- long-term surface water availability across southern Victoria has declined by up to 21% due to drier conditions
- water availability for consumptive uses declined in most of southern Victoria, with declines ranging from 1% to 13%
- water availability for the environment declined in all basins except the Otway Coast.[1638]

[1634] Baldwin D 2022, 'Impacts of the 2019/2020 Black Summer bushfires on water quality in north-east Victoria and Gippsland', a draft report to the Department of Environment, Land, Water and Planning (DELWP).
[1635] Ibid.
[1636] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Water is life: Traditional owner access to water roadmap. Draft for Consultation', Melbourne, Victoria.
[1637] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Guidelines for assessing the impact of climate change on water availability in Victoria, final', Melbourne, Victoria.
[1638] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Long term water resource assessment for southern Victoria, overview report', Melbourne, Victoria.

Inland waters

A LTWRA of Victoria's northern rivers, which are part of the Murray-Darling Basin, will be conducted in 2024. In the meantime, a 2020 submission by the Interim Inspector-General of Murray-Darling Basin Water Resources reported that, for the basin 'the median annual inflow over the past 20 years is approximately half that of the preceding century. More significantly, the frequency of drier years is also much greater,'[1639] It was also reported that 'the pattern of such dry years occurring back-to-back is also not observable to the same extent at any other time prior to 2000.'[1640]

Table WR3 presents data on population growth, climate change and waterway condition for five Melbourne regions and nine rural regions. Population growth by 2040 in the Melbourne regions ranges from 25% to 135%, while in the rural regions, population growth ranges between a 6% decrease in the Wimmera (the only region to experience a decrease) to a 54% increase in Goulburn Broken. Such growth will place greater pressure on water resources already impacted by climate change. In the Melbourne regions, temperatures are expected to increase by 1.3°C by 2040, and rainfall to decrease by 2.4%. The picture is more varied in the rural regions, with temperature increases ranging from 0.5°C to 2.6°C and rainfall decreases ranging from 3.7% to 14%.

Table WR3 also provides data on waterway condition in each of the rural regions. Waterway condition generally deteriorates from east to west, with the East Gippsland, Gippsland and North East regions in better condition than those in the state's south-west, in particular the Barwon, Moorabool and Hopkins river basins. The remaining regions have largely moderate waterway condition.

Table WR3: Threats to waterways in metropolitan and regional catchments.[1641, 1642, 1643, 1644, 1645, 1646, 1647, 1648, 1649, 1650, 1651, 1652, 1653, 1654, 1655, 1656, 1657, 1658, 1659, 1660, 1661]

Region	Population growth	Climate change	Waterway condition
Metropolitan			
Dandenong	25% increase by 2040	1.3°C increase in temperature by 2040 2.4% decline in rainfall by 2040	n/a
Maribyrnong	57% increase by 2040		Stormwater runoff increase by 25% by 2050
Yarra	44% increase by 2040		n/a
Werribee	135% increase by 2040		Stormwater runoff increase by 110% by 2050
Western Port	100% increase by 2040		n/a

1639. Interim Inspector-General of Murray-Darling Basin Water Resources 2020, 'Impact of lower inflows on state shares under the Murray–Darling Basin Agreement', Canberra, Australian Capital Territory.
1640. Ibid.
1641. Department of Environment, Land, Water and Planning (DELWP) 2018, 'Central Highlands strategic directions statement', Melbourne, Victoria.
1642. Department of Environment, Land, Water and Planning (DELWP) 2018, 'Coliban strategic directions statement', Melbourne, Victoria.
1643. Department of Environment, Land, Water and Planning (DELWP) 2018, 'East Gippsland strategic directions statement', Melbourne, Victoria.
1644. Department of Environment, Land, Water and Planning (DELWP) 2018, 'Goulburn Broken strategic directions statement', Melbourne, Victoria.
1645. Department of Environment, Land, Water and Planning (DELWP) 2018, 'Dandenong strategic directions statement', Melbourne, Victoria.
1646. Department of Environment, Land, Water and Planning (DELWP) 2018, 'Western Port strategic directions statement', Melbourne, Victoria.
1647. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Gippsland strategic directions statement', Melbourne, Victoria.
1648. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Great South Coast strategic directions statement', Melbourne, Victoria.
1649. Department of Environment, Land, Water and Planning (DELWP) 2019, 'North East strategic directions statement', Melbourne, Victoria.
1650. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Werribee strategic directions statement', Melbourne, Victoria.
1651. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Yarra strategic directions statement', Melbourne, Victoria.
1652. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Maribyrnong strategic directions statement', Melbourne, Victoria.
1653. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Wimmera strategic directions statement', Melbourne, Victoria.
1654. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Barwon strategic directions statement', Melbourne, Victoria.
1655. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Werribee catchment integrated water management plan', Melbourne, Victoria.
1656. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Yarra catchment integrated water management plan', Melbourne, Victoria.
1657. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Dandenong catchment integrated water management plan', Melbourne, Victoria.
1658. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Maribyrnong catchment integrated water management plan', Melbourne, Victoria.
1659. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Western Port catchment integrated water management plan', Melbourne, Victoria.
1660. Department of Environment, Land, Water and Planning (DELWP), 'What we are delivering for regional Victoria', https://www.water.vic.gov.au/__data/assets/pdf_file/0022/604453/Maps2017-2022-27-10-2022.pdf Accessed 20 April 2023.
1661. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Integrated water management: progress report', Melbourne, Victoria. https://www.water.vic.gov.au/__data/assets/pdf_file/0038/563888/IWM-Progress-Report-V08-reduced-file-size.pdf Accessed 3 August 2023.

Region	Population growth	Climate change	Waterway condition
Regional			
North East	20% increase by 2040	1.4°C by 2040 and 2.5°C by 2065 3.7% decline in rainfall by 2065	40% good 50% moderate <7% in poor
Goulburn Broken	54% increase by 2040	2-3°C increase by 2065 4% decrease in rainfall by 2065	21% excellent 18% good 44% moderate 13% poor 4% very poor
East Gippsland	22% increase by 2035	1.3-2.4°C increase by 2040 4.25% decrease in rainfall by 2030	82% good to excellent
Coliban	35% increase by 2040	1.7-2.6°C by 2070 5% decline in rainfall by 2070	Most moderate
Central Highlands	40% increase by 2040	1.4-2.5°C increase by 2070 6-7% decrease in rainfall by 2070	Corangamite CMA: 46% moderate North Central CMA: 50% moderate
Barwon	30.5% increase by 2036	0.5-1.5°C increase by 2040 14% decrease in rainfall by 2040	Barwon: 4% good 37% moderate 41% poor 41% 17% very poor Moorabool: 0% good 57% moderate 5% poor 38% very poor
Wimmera	6% decrease by 2036	1.6-2.2°C increase by 2050 5-12% decrease in rainfall by 2050	58% moderate
Great South Coast	2.3% increase by 2031	1.3-2.4°C by 2070 6-7% decrease in rainfall by 2070 20-50% decrease in runoff by 2065	Portland basin: 84% moderate Glenelg basin: 68% moderate Hopkins basin: 94% poor to very poor
Gippsland	30% increase by 2040	2.1-2.4°C by 2065 2.2-4.5% decrease in rainfall	33% good to excellent 53% moderate

Healthy flows in Victoria's rivers are critical to cultural, social, economic and environmental wellbeing. However, up to half of Victorian river flows are diverted to supply farms, homes and industries, with diversions higher in dry years.[1662] In 2020–21, there were 5,379 Victorian farms using 1.64 million ML of water for irrigation of cereal crops, pastures, fruit and vegetables, nuts, vines, rice and flowers.[1663]

1662. Victorian Environmental Water Holder 2017, 'Reflections water for the environment in Victoria 2016-2017', http://www.vewh.vic.gov.au/__data/assets/pdf_file/0010/445564/Reflections-Water-for-the-Environment-2016-2017.pdf Accessed 3 December 2018.

1663. Australian Bureau of Statistics (ABS), 'Water use on Australian farms 2020-21' https://www.abs.gov.au/statistics/industry/agriculture/water-use-australian-farms/latest-release#data-download Accessed 18 April 2023

Inland waters

Most Victorian catchments, rivers and larger streams have been modified, with inland waters transformed into a complex and extensive water grid for harvesting, transporting and controlling the movement of water. Many are now environmentally degraded.[1664] As surface water supply comes under increasing pressure, greater attention is now being given to increasing the supply of manufactured water — seawater desalination, wastewater recycling and stormwater treatment — to fill the gaps.

Without efficient, sustainable, integrated and coordinated management of Victoria's water resources, the future wellbeing of Victorians would be at risk. The Water for Victoria plan was released in 2016 and committed the Victorian Government to introducing an integrated water management (IWM) framework to improve water security, public and environmental health, and urban amenity.[1665] More detail on the implementation of the framework is found below in 'Integrated water management'.

The reform of water resource planning and management is a critical step to help ensure Victoria has a secure and reliable water supply for its people and the environment. However, achieving the outcomes of such reform are not without challenges, including meeting the water consumption needs of Victoria's growing population, which is projected to reach 11 million by 2056, and the needs of agriculture at a time of climate change when, for example, stream flow in the Central and Gippsland regions has declined by 21% since 1975.

Currently Melbourne's residents consume 50 to 70 GL more water each year than flows into storages, with desalinated water filling the gap.[1666] In the Central and Gippsland regions, it is projected that at least an additional 200 GL of water could be needed over the next 10 years for urban water supplies, irrigation, Traditional Owners and the environment. Satisfying all water users and the environment will be challenging, as are:

- increasing the use of water available from the treatment of stormwater and the recycling of wastewater
- addressing water resource availability and flow regimes to support aquatic life
- ensuring that commitments made to Traditional Owners are fulfilled
- delivering ongoing sustainable IWM solutions
- managing the impact of emerging water users, such as the expansion of water-intensive almond plantations in the Mildura area
- ensuring that extraction caps for surface water and groundwater are based on the best-available science, are adaptive to the impacts of climate change, and factor in an environmentally sustainable level of take.[1667]

1664. Department of Environment, Land, Water and Planning (DELWP) 2014, 'Dams in Victoria', https://www.water.vic.gov.au/__data/assets/pdf_file/0018/54126/Dam-Safety-Factsheet-FINALv4b.pdf Accessed 3 December 2018.
1665. Department of Environment, Land, Water and Planning (DELWP) 2017, 'Integrated water management framework for Victoria. An IWM approach to urban water planning and shared decision making throughout Victoria', Melbourne, Victoria.
1666. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Central and Gippsland region sustainable water strategy', Melbourne, Victoria.
1667. The Commonwealth *Water Act 2007* gives environmental priorities primacy in its objects and water allocations, whereas in the Victorian *Water Act 1989*, making sure that water resources are conserved and properly managed for sustainable use for the benefit of present and future Victorians is just one of 14 purposes.

Integrated Water Management

Bendigo Creek, a waterway central to the City of Bendigo's urban landscape, is being restored to its pre-European condition by the Djandak (Dja Dja Wurrung Enterprise), using ponds, weed removal and revegetation, and combining traditional ecological knowledge with science, design and engineering. The Wanyarram Dhelk, Bendigo Creek Restoration — in Djaara language, Wanyarram Dhelk means Good Waterhole — will heal Country, return fibre and food sources to the Bendigo Creek, and filter contaminants and nutrients from stormwater.

The project is one of many being funded to implement the Integrated Water Management Framework 2017, including drought-proofing of the Cranbourne Royal Botanic Gardens. That project has a one-kilometre pipeline from the Eastern Treatment Plant delivering water to the gardens where it is treated before watering 100,000 native plants.

Figure WR1 compares conventional water management with the IWM approach.

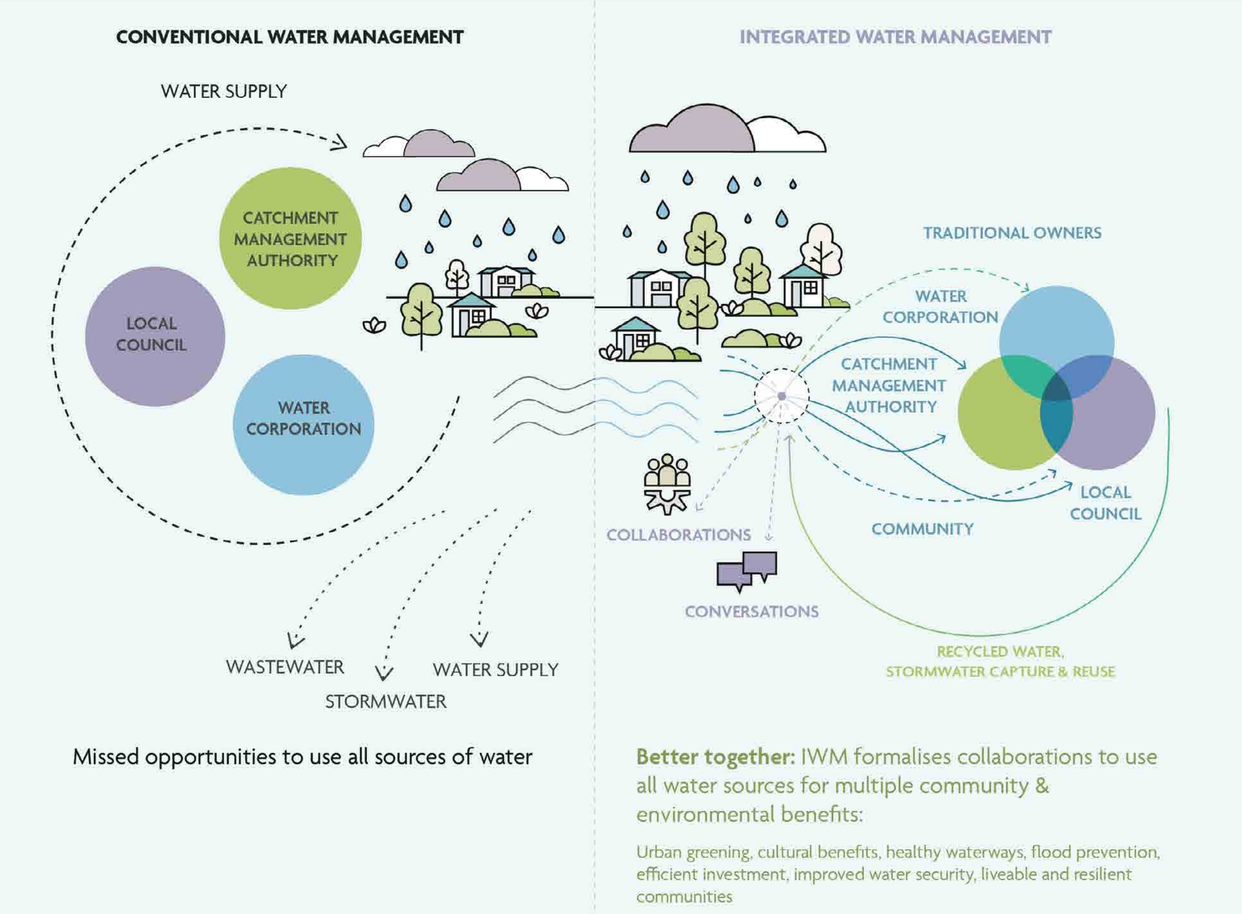


Figure 1: How does IWM work? Conventional water management saw a more siloed approach to water management, with a single supply source and two discharge systems to move stormwater and wastewater away as quickly as possible, resulting in missed opportunities to use all sources of water. The IWM approach brings water managers together to plan and deliver new opportunities to provide broader benefits to the community. Listening to and consulting with Victorian communities about how they want water managed is critical to informing IWM decision making. Communities are directly consulted on IWM Plans and through existing Catchment Management Authority, Water Corporation and Local Government strategies.

Figure WR1: Conventional water management compared to IWM.[1669]

1668. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Integrated water management progress report', Melbourne, Victoria.

‘Conventional water management saw a more siloed approach to water management, with a single supply source and two discharge systems to move stormwater and wastewater away as quickly as possible, resulting in missed opportunities to use all sources of water. The IWM approach brings water managers together to plan and deliver new opportunities to provide broader benefits to the community. Listening to and consulting with Victorian communities about how they want water managed is critical to informing IWM decision-making. Communities are directly consulted on IWM plans and through existing CMA, Water Corporation and Local Government strategies.’ [1670]

The Integrated Water Management Framework 2017 aims to achieve the following seven outcomes:

- safe, secure and affordable water supplies in an uncertain future
- effective and affordable wastewater systems
- managed existing and future flood risks and impacts
- healthy and valued waterways and marine environments
- healthy and valued urban, rural, agricultural and green landscapes
- community values are reflected in planning
- jobs, economic growth and innovation.[1671]

To implement the framework, 15 IWM forums were established in metropolitan and regional Victoria. These brought together 100 organisations interested in the water cycle who helped identify IWM opportunities for catchments in metropolitan Melbourne and regional towns and cities, and strategic direction statements for each region.

Five catchment-scale IWM plans have been prepared for the major water catchments of metropolitan Melbourne. IWM plans will also be prepared for some regional towns and cities. Overall outcomes of the framework's implementation to date include:

Fifteen stormwater and recycled water projects that will supply 15 sporting ovals, three golf courses, 21 parks and open public spaces, nine schools and colleges, conservation parklands and Werribee Open Range Zoo and annually save 1 GL of drinking water

Water for the environment

Reporting on environmental watering outcomes

Water for Victoria is the Victorian Government’s strategic plan for managing its water resources, now and into the future.[1671] Recognising the importance of reporting progress towards expected environmental outcomes from environmental watering, Action 3.6 from Water for Victoria contains a requirement for the Commissioner for Environmental Sustainability (CES) to ‘report on the outcomes of environmental watering in Victoria, as part of the five-yearly SoE Report’ and ‘recommend ways to improve future public reporting.’ [1672]

To deliver Action 3.6 from Water for Victoria and report on the outcomes of environmental watering in Victoria, the CES will work with the same definition of environmental water that was used in Water for Victoria - ‘water to support environmental values and ecological processes’.

Indicator ‘WR:08 Condition of flow regimes’ details how streamflow within Victorian river basins compares to the long-term averages and explores the relationship between streamflow and rainfall. The assessment is undertaken for all river basins where there is measured streamflow data. A narrower scope is taken in the assessment of ‘WR:09 Delivering water for the environment’ to focus on rivers and wetlands where water for the environment is delivered. In this way the two indicators are complementary, with WR:08 looking at the condition of flow regimes more broadly and can be used to identify river systems under stress, while WR:09 details the impact of water for the environment delivery on river and wetlands where water is delivered.

A synthesis of environmental and community outcomes from water for the environment are also included, providing a pathway to a comprehensive, whole-of-system approach to report on environmental watering outcomes in the SoE 2028 Report.

[1669] Department of Environment, Land, Water and Planning (DELWP) 2022, ‘Integrated water management progress report’, Melbourne, Victoria.

[1670] Ibid.

[1671] Department of Environment, Land Water and Planning (DELWP) 2016, ‘Water for Victoria water plan’, Melbourne, Victoria https://www.water.vic.gov.au/__data/assets/pdf_file/0030/58827/Water-Plan-strategy2.pdf Accessed 14 March 2023.

[1672] Ibid.

What is environmental water and why is it needed?

Water is essential to life but is a limited resource. These two properties make water a key component of sustainable development and increases the importance of appropriately balancing the water allocations for consumption and the environment, particularly given the influence of a drying climate reducing the amount of water and a growing population increasing the demand for water.

Many of Victoria's river systems have been modified to provide water for towns, industry and food production as the state has prospered and experienced population growth. Instead of flowing naturally through the landscape, some water is now captured in dams and weirs, and then diverted for human use via pipes and man-made channels. As a result, some of our rivers give up more than a third — and sometimes half — of the water that would have naturally flowed in them throughout each year.[1673]

Environmental water is water that is managed to improve or maintain the health of rivers, floodplains, wetlands and estuaries — including the plants and animals that depend on them.

Balancing consumptive and environmental-water use in Victoria has been a critical part of water policy in Victoria since the 1990s. Water extractions of any volume from surface water or ground water will change natural systems, and often in significant ways with ecological, biological, chemical or geomorphic impacts. It is important to note that these biophysical impacts are highly likely to have an impact on social, cultural, economic and recreational benefits and values. Providing water for the environment can protect or restore biophysical values and sustain and enhance the various water-dependent social, cultural and economic values.

Policy and legislative settings

The policies and legislative settings described in this section can have relevance to both the water quality and water resource indicator assessments.

Water quality

Actions to maintain and improve water quality in Victoria are in part guided by Australian and New Zealand Water Quality Guidelines, which also include a Water Quality Management Framework which is a systematic approach to the management and assessment of water quality. Key elements of the framework include community values, monitoring, stakeholder engagement and the weight of evidence.

Water quality management in Victoria is the responsibility of DEECA, EPA Victoria, Melbourne Water, other water corporations, and CMAs which develop and implement waterway management strategies.

The Victorian *Water Act 1989* provides the framework for the allocation of surface water and groundwater water across the state.

The *Safe Drinking Water Act 2003* places obligations on water suppliers to supply safe, good quality drinking water and provides a regulatory framework that includes a risk management framework 'from catchment to tap'. The National Health and Medical Research Council's Drinking Water Guidelines provide guidance to water regulators and suppliers on monitoring and managing the quality of drinking water.

In 2021, the new *Environment Protection Act 2017 (EP Act)* was enacted. In that same year, the water quality objectives of SEPPs were superseded by the ERS, which is a tool in the *EP Act*. The ERS covers ambient air, ambient sound, land and water (surface water and groundwater) and identifies environmental values that the Victorian community want to achieve and maintain. It also provide s a way to assess those environmental values in locations across Victoria. Most of the values are accompanied by indicators and objectives to assess whether that value is being met. The Australian and New Zealand Water Quality Guidelines are heavily referenced in the ERS.

The EP Act specifies that EPA Victoria's objective is to protect human health and the environment by reducing the harmful effects of pollution and waste. The Authority is an independent statutory body that administers its Act and various regulations designed to manage risks to water quality.

[1673] Victorian Environmental Water Holder (VEWH), 'What is water for the environment?', https://www.vewh.vic.gov.au/water-for-the-environment/what-is-water-for-the-environment Accessed 3 January 2023.

Inland waters

The EP Act also includes 11 principles of environmental protection, sets out the legislative framework for the protection of human health and the environment from pollution and waste, and provides a framework for the management of waste. Within the EP Act, the general environmental duty applies to all Victorians who must reduce the risk of harm from their activities, pollution and waste to human health and the environment.

EPA Victoria's Strategic Plan 2022-2027 defines the agency's purpose, the outcomes sought during the life of the plan, and how performance is measured against those outcomes. The three outcomes are:

- Victoria's environment is cleaner, and its communities are healthier
- all Victorians reduce their environmental risks
- EPA Victoria has impact and influence.[1674]

The strategic plan's performance measure of most relevance to this theme is 'Percentage of pollution report requiring a field response by EPA Victoria due to possible human health and/or environmental impacts.'[1675]

Melbourne Water's responsibility is to create long-term plans that ensure the region's rivers, wetlands and estuaries are healthy, liveable and accessible. Melbourne Water's Healthy Waterways Strategy 2018-2028 is intended to address future urban waterway management needs and has a 50-year outlook.[1676] The strategy identifies 11 waterway values that include biological, social, economic and cultural, along with five waterway conditions: water quality, habitat, stormwater, vegetation and water for the environment.

The Healthy Waterways Strategy 2018-2028 has been developed for the Port Phillip and Westernport region. For each of the five major catchments within the region (Werribee, Maribyrnong, Yarra, Dandenong and Westernport), the strategy outlines catchment-specific visions, goals, long-term targets (10 to 50 years) for key values and waterway conditions, and short-term performance objectives (10-years). Effort and investment at catchment and sub-catchment scale are prioritised and aligned to ensure they contribute to broader, regional goals and outcomes.

The Central and Gippsland Region Sustainable Water Strategy (CGRSWS) released in 2022 commits to implement (or develop where necessary) plans aimed at helping reach marine pollutant load objectives in Corner Inlet, Westernport, Port Phillip Bay and Lake Wellington. The CGRSWS also contributes to protecting water quality by returning up to 99.5 GL of water to major rivers across southern Victoria over the next 10 years to help to maintain flows in a drying climate

The Victorian Waterway Management Strategy aims to maintain, or improve, the condition of our waterways so they can support environmental, social, cultural and economic values that are important to communities. It provides direction for regional decision-making, investment and management issues for waterways, as well as the roles and responsibilities of management agencies. Regional waterway strategies are developed by CMAs.

Urban and rural water corporations supply water and manage wastewater, while CMAs engage their communities in catchment and riparian restoration activities.

The RWMP involves around 52 organisations which invest in a single, coordinated and efficient approach to collect surface water and groundwater data that can meet multiple business needs. The data are publicly available on the WMIS website.[1677]

Waterwatch is a community engagement program that encourages citizen scientists to gather data and monitor water quality in their local waterways and wetlands. It has an associated program called EstuaryWatch.

Water resources

The *Water Act 2007* (Cth) provides the legislative framework for ensuring that the Murray–Darling Basin is managed in the national interest. The Murray–Darling Basin Authority operates under the Act. The Commonwealth Water Act requires an environmentally sustainable level of take to be set, and environmental priorities to be given primacy when establishing water allocations.

1674. Environment Protection Authority (EPA) Victoria 2022, 'Strategic plan 2022-2027', Carlton, Victoria.
1675. Ibid.
1676. Melbourne Water Corporation 2018, 'Healthy waterways strategy 2018-2028', Melbourne, Victoria.
1677. Department of Energy, Environment and Climate Action (DEECA), 'Surface water monitoring', Melbourne, Victoria, https://www.water.vic.gov.au/water-reporting/surface-water-monitoring Accessed 8 July 2023.

Inland waters

Maximising net economic returns from the use and management of water resources, also an object of the Commonwealth Water Act, is subject to two other objects: 'to ensure the return to environmentally sustainable levels of extraction for water resources that are overallocated or overused' and 'to protect, restore and provide for the ecological values and ecosystem services of the Murray-Darling Basin.'[1678]

The Basin Plan, prepared by the Murray–Darling Basin Authority, is a coordinated approach to water management across the Murray–Darling Basin's four states (Victoria, South Australia, New South Wales and Queensland) and the Australian Capital Territory. It is designed to ensure that water taken from the Murray–Darling Basin for consumptive use is sustainable. Under the plan, each basin state must develop water resource plans that set rules on the volume of water available for extraction and the environment, as well as how standards for water quality can be met.

The Victorian Government manages the allocation of water resources across the state in accordance with the Victorian Water Act. The state's water entitlement and planning framework defines how water is shared, held, used and traded to support agricultural, urban and environmental water needs and ensures planning processes are in place so that future water needs can be met. The Victorian Water Act provides the framework for managing Victoria's surface and groundwater.

Its main purpose is to:

- promote the equitable and efficient use of our water resources
- make sure the state's water resources are conserved and properly managed for the benefit of all Victorians
- increase community involvement in conserving and managing the state's water resources.

The Victorian water entitlement framework sets out the ways in which individuals, companies, government and water corporations can share water. The elements of the entitlement framework are:

- secure entitlements to water
- tools to set limits on how water is used
- provision for sharing of water between urban, irrigator and environmental users, including when water availability is reduced
- the ability for individuals to manage their own risks by being able to trade and carry over unused water allocation to the next water year
- clear, consultative processes before entitlements can be changed
- private rights enabling individuals to take water for domestic and stock purposes in certain circumstances without a licence
- Traditional Owners' rights to water.

In October 2016, the Victorian Government released Water for Victoria, a plan for the management of Victoria's water resources now and in the future.[1679] Water for Victoria includes commitments to improve Victoria's existing waterway monitoring programs, invest in community partnerships and citizen-science initiatives, and strengthen integrated catchment and water management.

The Integrated Water Management Framework, released in 2017, aims to provide:

> 'a consistent process for collaborative IWM planning with clear roles and responsibilities to deliver effective urban water management, including water supply, wastewater, flood resilience, urban waterway health and management of public spaces.' [1680]

[1678] Australian Government, 'Water Act 2007', https://www.legislation.gov.au/Details/C2021C00539 Accessed 3 August 2023.

[1679] Department of Environment Land, Water and Planning (DELWP) 2018, 'Water for Victoria', Melbourne, Victoria.

[1680] Department of Environment Land, Water and Planning (DELWP) 2017, 'Integrated water management framework for Victoria: An IWM approach to urban water planning and shared decision making throughout Victoria', Melbourne, Victoria.

Inland waters

Since 2016, the Water for Victoria plan has underpinned the Victorian Government's response to the challenges of population growth and climate change. As of July 2022, 52 of the 69 actions in the plan had been completed, and the remainder were in progress.[1681] 'The actions range from flagship waterway projects, protecting and restoring waterway health, supporting farmers' resilience with new infrastructure and skills, and partnering with Traditional Owners to better include Aboriginal water interests into water planning and management.' [1682] Five-yearly assessments of Water for Victoria are informed by monitoring and annual reporting and provide additional catchment inflow data. They also check on the progress of actions to identify the support needed to finalise them in the last five years of the planning cycle.

Sustainable Waterway Strategies identify threats to water availability and water quality and include proposed policies and actions to manage those threats over the next 50 years. The strategies provide multiple actions and policies at a regional scale to manage threats to water resources, including climate change, population growth and land-use change. They are initiated under the Victorian Water Act and must be reviewed after 10 years. A Sustainable Water Strategy has been developed for each of three regions covering Victoria — Central and Gippsland (2022), Northern (2009) and Western (2011) regions.

The Victorian Waterway Management Strategy was released in 2013 (a new strategy is under development). It provides the framework for government, in partnership with the community, to maintain or improve the condition of rivers, estuaries and wetlands so that they can continue to provide environmental, social, cultural and economic values for all Victorians. Regional waterway strategies, which are a requirement under the Victorian Water Act, drive implementation of the management approach outlined in the Victorian Waterway Management Strategy.

The regional strategies are developed by CMAs and Melbourne Water in partnership with other regional agencies, authorities and boards involved in natural resource management, as well as Traditional Owners, regional communities and other key stakeholders.

In 2022, urban water corporations updated their Urban Water Strategies (UWS) to provide a system view of water resource management in Victoria's cities and towns over the next 50 years. To date, 12 of the 13 UWSs have been publicly released, with the final Greater Melbourne Urban Water and System Strategy covering metropolitan Melbourne due for release in 2023. UWSs are updated every five years.

The Victorian water sector is implementing the Water Cycle Climate Change Adaptation Action Plan 2022-2026. The plan contains 19 actions aimed at building resilience to climate change and to 'support the water sector to harness opportunities that may arise through climate action'.[1683] It is one of seven such plans prepared under Victoria's *Climate Change Act 2017.*

The *Yarra River Protection (Wilip-gin Birrarung murron) Act 2017* prescribes how a long-term Community Vision and a Yarra Strategic Plan, which gives effect to the vision, are developed. The Yarra River Protection Act also prescribes the establishment of a new statutory body, the Birrarung Council, to be the first independent voice of the Yarra River as part of recognising it as a living entity. The Birrarung Council now provides independent advice to the Victorian Government on, and advocates for, protecting and improving the Yarra River.

The VicWaCI 2017-2024 is a research partnership between DEECA, BOM and the *Commonwealth Scientific and Industrial Research Organisation* (CSIRO). The Initiative supports research into the impact of climate change and climate variability on Victoria's water resources.

The Groundwater Management 2030 (GM2030) was released by DELWP in August 2022 and provides a set of priorities for the reform of groundwater management and licensing.

1681. Department of Energy, Environment and Climate Action (DEECA), 'Water for Victoria', https://www.water.vic.gov.au/water-for-victoria Accessed 8 July 2023.
1682. Department of Environment, Land, Water and Planning (DELWP) 2016, 'Water for Victoria: Water plan', Melbourne, Victoria.
1683. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Water cycle climate change Adaptation Action Plan 2022-2026', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0025/558421/WaterCycleAdaptationActionPlan.pdf Accessed 23 June 2023.

GM2030 sets out 13 Priority Areas across three outcomes to achieve:

- an improved, shared understanding of groundwater and its uses for evidence-based management
- modern tools in the state-wide framework for flexible and cost-effective groundwater management
- streamlined and effective licensing, trade rules and controls on groundwater use that support changing water uses.

The Our Catchments, Our Communities Strategy (2016-2019) aims to maintain healthy, sustainable and productive land, water and biodiversity in the state through integrated catchment management that is strongly community-based, regionally focused and collaborative.

The Victorian Rural Drainage Strategy sets out new rules, protocols, and support mechanisms to enable landholders and government agencies to overcome past barriers to the repair and management of degraded rural drainage systems. Landholders are supported to make choices about how they want to manage dryland rural drainage through a series of actions and policies.

The Victorian Floodplain Management Strategy is designed to ensure appropriate response and action is taken in the event of a flood. It clarifies the roles and responsibilities of government agencies and authorities involved in flood management. The strategy also encourages communities and individuals to work with their council and CMAs to decide on the level of flood mitigation that best suits their locality.

The Aboriginal Water Program is a partnership between DEECA, Traditional Owners and Aboriginal Victorians to manage waterways and catchments across the state and reconnect communities to water for cultural, economic, customary and spiritual purposes.

The objectives of the Aboriginal Water Program are to:

- recognise Aboriginal values and objectives of water
- include Aboriginal values and traditional ecological knowledge in water planning
- support Aboriginal access to water for economic development
- strengthen capacity to increase Aboriginal participation in water management.

Water is Life: Traditional Owner Access to Water Roadmap, was released in late September 2022. It was developed by the Aboriginal Water Unit working in close partnership with Traditional Owners from across Victoria. Water is Life provides an important framework to create and maintain a careful and considered balance between Traditional Owner self-determination in water access and management, and the rights and entitlements of a range of stakeholders.[1684]

The Yarra Strategic Plan 2022-32 aims to deliver an integrated river corridor strategy that:

- identifies immediate actions for the river
- enables long-term, collaborative management between Traditional Owners and agencies involved in management of the Yarra River and its lands
- guides local planning
- requires the development of a long-term community vision that identifies the community's values, priorities and preferences about the management of the Yarra River corridor.

The LTWRA for southern Victoria was released by DELWP in 2020. The Central and Gippsland Region Sustainable Water Strategy was released in 2022. However, the LTWRA for Victoria's northern basins has been delayed until 2025 to allow it to provide advice to the review of the Murray-Darling Basin Plan due in 2026. The preparation of LTWRAs will ultimately be aligned with the Sustainable Water Strategies.

The *Heritage Rivers Act 1992* identifies 18 Heritage River Areas in Victoria. The Heritage Rivers Act protects public lands in specific parts of heritage river areas or river catchments with significant recreation, conservation, scenic or cultural heritage values.

[1684] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Water, community and Country: Victoria's Aboriginal water program, progress snapshot, September 2020', Melbourne, Victoria.

Water for the environment

Management of environmental water entitlements in Victoria

The Government manages the allocation of water resources across the state in accordance with the Victorian Water Act. Under the Water Act, the Victorian Government retains the overall right to the use, flow and control of all surface water and groundwater on behalf of all Victorians.[1685]

The Environmental Water Reserve (EWR) is the legal term used to describe the amount of water set aside to meet environmental requirements in Victoria. The Water Act defines the EWR and states that the objective of the EWR is that the EWR is maintained to preserve the environmental values and health of water ecosystems, including their biodiversity, ecological functioning and quality of water, and the other uses that depend on environmental condition.[1686] Water for the environment is provided under the EWR in three ways:

- An 'environmental entitlement' is a legal right to take and use water granted under the Water Act for the purpose of maintaining an EWR or improving the environmental values and health of the water ecosystems and other users that depend on environmental condition.
- Obligations and conditions on consumptive use most commonly encompass 'passing flows' that specify the volume of water that water corporations or licensed diverters are obligated to provide before water can be taken for consumptive use.
- 'Above cap water' is the water that is available to the environment once limits on consumptive volumes of surface water and groundwater have been reached. The largest component of the EWR is above cap water, which is important given above cap water is not secure and is most at risk under climate change.

Indicator 'WR:08 Condition of flow regimes' has been designed to start with an overall analysis of streamflow across river systems in Victoria that is complemented by subsections that focus on influential factors (e.g. climate change, rainfall, runoff and environmental water delivery). This means that the indicator scope encompasses the complete influence of water for the environment on flow regimes (that is, not just the influence of environmental entitlements). Furthermore, the indicator scope is broader than just water for the environment, with the wider lens providing important context for the many interactive human and natural influences on flow regimes.

Indicator 'WR:09 Delivering water for the environment' focuses on the delivery of environmental entitlements and the achievement of flow recommendations in regulated systems. This is because these are the only water entitlements that can be actively managed — these entitlements are used for delivery by the relevant environmental water manager at a time and in a manner that will best meet the needs of the environment. Obligations and conditions on consumptive use are not incorporated within the indicator assessment as there have been no major breaches of passing flow compliance in any of the past five years (as reported in the Victorian Water Accounts reports from 2016-17 to 2020-21).[1687, 1688, 1689, 1690, 1691] Likewise, above cap water is not included within the WR:09 indicator assessment as the volume of above cap water could not be quantified for the most recent year (2020-21) Victorian Water Accounts report, and this precludes meaningful analysis on how this part of the EWR is used to meet environmental requirements.

Defining the scope of the indicators relating to environmental water highlights an ongoing issue facing those managing delivery of, and reporting the outcomes from, water for the environment — it is a complex sector influenced by a range of natural phenomena and human interventions. In keeping with the broad definition of environmental water that was used in Water for Victoria: 'water to support environmental values and ecological processes', environmental water indicators are designed to have a wide scope to highlight the overall effect of water for the environment. Where suitable, this has been complemented by focused analyses.

[1685] State Government of Victoria, 'Water Act 1989', Authorised Version No. 138, https://content.legislation.vic.gov.au/sites/default/files/2022-08/89-80aa138%20authorised.pdf Accessed 14 March 2023.

[1686] Ibid.

[1687] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2016-17', Melbourne, Victoria.

[1688] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2017-18', Melbourne, Victoria.

[1689] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2018-19', Melbourne, Victoria.

[1690] Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian water accounts 2019-20', Melbourne, Victoria.

[1691] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.

Regulated and unregulated systems

A river system comprising one or more rivers can be regulated or unregulated. CES reporting on environmental watering outcomes primarily focuses on regulated systems.

A regulated system is a system in which the flow of water is stored or otherwise controlled (regulated) by storages and weirs that regulate the supply or extraction of water for consumptive use.[1692] In regulated systems, environmental water is mainly 'set aside' through environmental water entitlements or water shares. Managed environmental water is vital in regulated river systems where water storages and extraction alter natural streamflow. This can include a reduction in the size and frequency of flood events, as water is captured and stored for consumptive use, and reversal of seasonal flows (e.g. more flow occurs in summer for irrigation purposes and less in winter when there is generally more rain). Wetlands that do not, or rarely, receive natural inundation may also receive held environmental water.

By contrast, an unregulated system is a system where there are no major storages or weirs to regulate supply or consumptive-use extraction. Groundwater systems are also unregulated.[1693] It is important to note that 'unregulated' refers to the absence of major storages or weirs and does not mean an absence of rules or regulations about how water may or may not be extracted or used.

In unregulated systems and in groundwater aquifers, environmental water is primarily provided through management of existing diversions via licence conditions, rostering and restriction rules (water left in the system contributes to environmental needs but cannot be actively managed). In unregulated systems it is also vital that a sustainable level of water remains in the waterway to allow environmental processes to take place. Licences and rules on diversion help protect this sustainable level.

Water for the environment governance structure and management agencies within Victoria and interjurisdictionally

Many different agencies are involved in managing the EWR and can be grouped into environmental water holders, public land managers, storage managers, Traditional Owners and waterway managers.

- Environmental water holders in Victoria are the VEWH and the Commonwealth Environmental Water Holder (CEWH). In addition, the Murray-Darling Basin Authority (MDBA), through the Southern Connected Basin Environmental Watering Committee, coordinate approval to deliver water entitlements on behalf of the Living Murray program; these entitlements are jointly held by the Commonwealth, New South Wales, Victoria, South Australian and the Australian Capital Territory governments. Environmental water holders work together to coordinate the delivery of water available under different environmental entitlements and prioritise watering across large regions. Further information on the existing monitoring and reporting of environmental watering outcomes done by these agencies is included in the 'Existing monitoring and reporting of environmental watering outcomes' section of this chapter.
- Public land managers are involved in the planning and delivery of environmental water for public land, such as state forests or national parks. Public land managers can include Parks Victoria, DEECA, and Traditional Owner land management boards. Land managers also play an important role in the delivery of complementary management actions, such as pest plant and animal control, which are critical to secure the outcomes from environmental watering.
- Storage managers deliver water for all water users, including for waterway managers and environmental water holders. The storage managers include Barwon Water, Central Highlands Water, Coliban Water, Grampians Wimmera Mallee Water, Goulburn-Murray Water, Lower Murray Water, Melbourne Water, Snowy Hydro and Southern Rural Water.

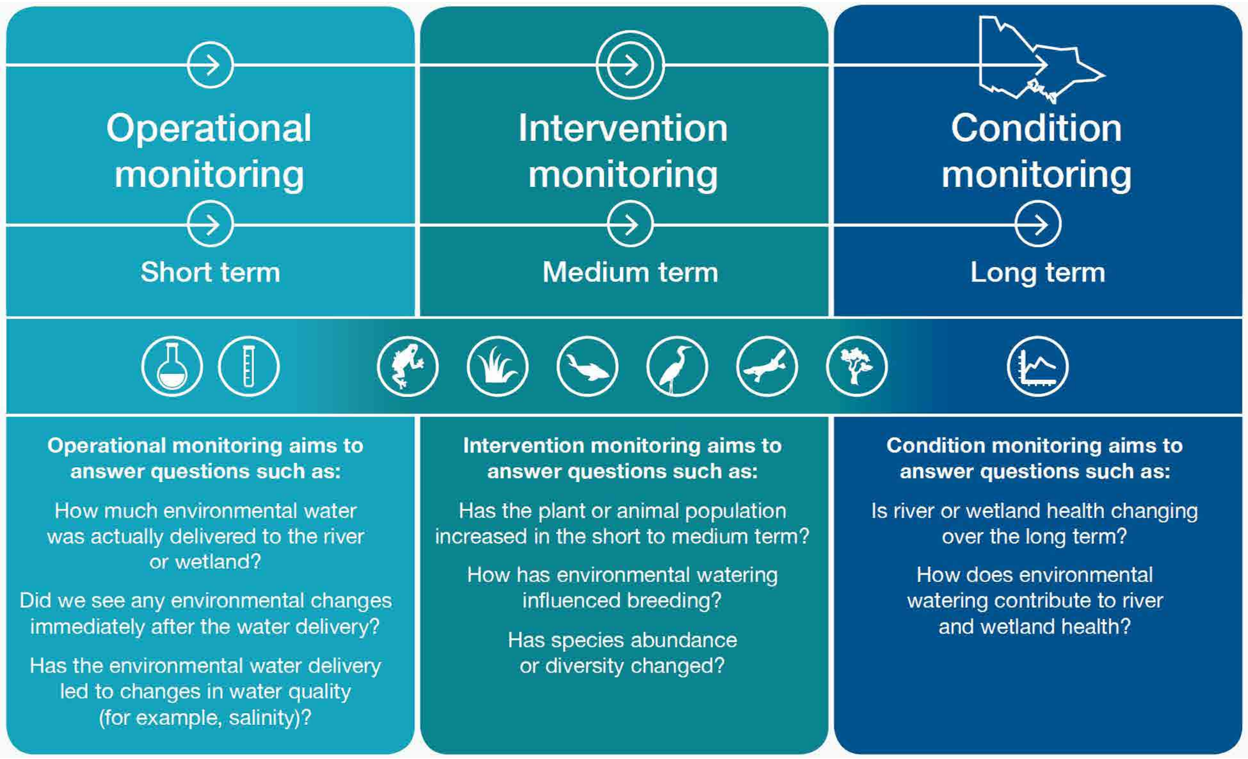
[1692] Department of Environment, Land Water and Planning (DELWP) 2022, 'Victorian water trading 2020-2021 annual report', Melbourne, Victoria, https://www.waterregister.vic.gov.au/images/documents/Victorian-Water-Trading-Annual-Report_2020-21.pdf Accessed 29 August 2022.

[1693] Ibid.

- Delivering water for the environment benefits plants and animals but can also help achieve cultural outcomes. As highlighted in Water is Life: Traditional Owner Access to Water Roadmap, for Traditional Owners all water on Country is integral to life itself and interconnected with the broader cultural landscape. Keeping as much water as possible in waterways is vital in achieving Healthy Country, Healthy Mob, and for self-determination. Outcome 6 of the roadmap is for legal recognition of Traditional Owners as environmental water holders — this would enable Traditional Owners to hold environmental entitlements (as well as other water entitlements) for the purpose of healing Country. These environmental entitlements would continue to be managed in accordance with the EWR objective and would be accounted for as environmental water under Victoria's water accounting frameworks.[1694] More information can be found in the 'Cultural landscape health and management' chapter of this report.
- Waterway managers are responsible for the management of rivers and wetlands, and work closely with public land managers. They consult with local communities, develop proposals for environmental watering in rivers and wetlands in their region, order environmental water from storage managers (on behalf of the environmental water holder), and monitor the outcomes. Waterway managers in Victoria include Catchment Management Authorities (CMAs) and Melbourne Water.

Existing monitoring and reporting of environmental watering outcomes

As illustrated in Figure WR2, environmental water monitoring in Victoria is undertaken over different time frames.



Operational monitoring aims to answer questions such as:

How much environmental water was actually delivered to the river or wetland?

Did we see any environmental changes immediately after the water delivery?

Has the environmental water delivery led to changes in water quality (for example, salinity)?

Intervention monitoring aims to answer questions such as:

Has the plant or animal population increased in the short to medium term?

How has environmental watering influenced breeding?

Has species abundance or diversity changed?

Condition monitoring aims to answer questions such as:

Is river or wetland health changing over the long term?

How does environmental watering contribute to river and wetland health?

Figure WR2: Types of environmental water monitoring in Victoria, and what they measure.[1695,1696]

[1694] Department of Environment, Land, Water and Planning (DELWP) 2022, 'The Aboriginal water program', https://www.water.vic.gov.au/aboriginal-values/the-aboriginal-water-program Accessed 3 August 2023.

[1695] Victorian Environmental Water Holder (VEWH) 2019, 'How do we know if environmental watering is successful?', Melbourne, Victoria, http://www.vewh.vic.gov.au/__data/assets/pdf_file/0005/342536/4.2.05-FS05_How-do-we-know-if-environmental-watering-is-successful_SWP_FS.pdf Accessed 14 March 2023.

[1696] Intervention monitoring is monitoring that is completed before, during and after an intervention event (e.g., monitoring before and after an environmental water delivery).

Inland waters

Current monitoring and reporting of environmental watering by the Victorian Government is generally focused on adding to the tactical intelligence to improve environmental water delivery. In this context, tactical intelligence refers to things like the best way to use environmental water at a given time, in a specific location and for the benefit of a particular species.

While the focus on analysis and reporting to increase the tactical intelligence likely leads to better localised management of environmental water, there is a knowledge gap with no quantitative analysis of environmental watering outcomes available to be produced at a statewide scale. This means there is a gap in the provision of strategic intelligence to help determine the appropriate balance for the amount of water allocated for the environment as opposed to consumptive use. This gap is highlighted in the provisional list of future environmental watering outcome indicators within Table WR17.

Beyond environmental and ecological benefits, environmental watering provides shared benefits. For example, supporting Aboriginal values with water that can be used for cultural purposes and increasing opportunities for recreational activities like fishing and boating.

Key findings from current monitoring and reporting of environmental watering by the Victorian Government are detailed in the 'Indicator assessments' section of this chapter, as well as being captured in the synthesis of research of environmental and community outcomes sub-sections. Significant monitoring and assessment projects and programs include:

- Every year, the VEWH report quantitatively on where environmental water has been used across the state, and qualitatively discuss the benefits that it provides — for the environment as well as shared benefits such as supporting Aboriginal or recreational values — via their Reflections publication series.
- Two environmental-flow monitoring and assessment programs have been established in consultation between DEECA, CMAs, Melbourne Water and VEWH to investigate ecological responses to environmental flows in rivers and wetlands. The information is used to evaluate the effectiveness of environmental flows in achieving intended ecological outcomes and provide new information to support flow-management decisions.
- The Victorian Environmental Flows Monitoring and Assessment Program (VEFMAP) helps investigate how waterway ecosystems respond to the release of environmental water, with a focus on fish and vegetation, so environmental water can be managed more effectively. The focus of VEFMAP involves collecting short- to medium-term monitoring data from priority rivers across Victoria. Monitoring is conducted before, during and after the delivery of environmental flows to examine the response of native fish and vegetation to different flow types. VEFMAP has been designed to complement other monitoring programs, and research is currently underway across Victoria and throughout the Murray-Darling Basin.[1697]
- The Wetland Monitoring and Assessment Program (WetMAP) is measuring the effect of environmental water delivery to re-establish more natural water regimes and to improve the health of wetlands. WetMAP represents a short- to medium-term approach for monitoring native fish, waterbirds, frogs and vegetation in a subset of Victoria's priority wetlands before and after environmental water delivery.[1698]
- Other monitoring and reporting mechanisms delivered at the regional scale — primarily by CMAs and Melbourne Water — include citizen science programs (e.g. bird and frog counts, Waterwatch water quality testing and Fluker Post photo monitoring). Monitoring results from such programs are reported back to communities via relevant advisory groups (e.g. site-specific Environmental Water Advisory Groups and Environmental Water Management Plans), websites, e-bulletins, social media, newspapers and annual reports.

1697. Department of Environment, Land, Water and Planning (DELWP), 'Environmental water', Melbourne, Victoria https://www.water.vic.gov.au/waterways-and-catchments/rivers-estuaries-and-waterways/environmental-water Accessed on 14 March 2023.
1698. Ibid.

- As a requirement of the Victorian Water Act, Government must complete a LTWRA every 15 years.[1699] Section 22L of the Water Act states that: 'A long-term water resources assessment must identify whether or not either or both of the following has occurred — a) there has been any decline in the long-term availability of surface water or groundwater and whether the decline has fallen disproportionately on the environmental water reserve or on the allocation of water for consumptive purposes; b) there has been any deterioration in waterway health for reasons related to flow.' [1700] A LTWRA for southern Victoria was published in 2020.[1701] An assessment for northern Victoria will commence in 2025 to align with the Murray-Darling Basin Plan review that is scheduled for 2026.[1702]

In addition to Victorian Government projects and programs for environmental water, The Living Murray (TLM) initiative is coordinated by the MDBA and commenced in 2002 to improve the ecological condition of icon sites (that is, priority environmental sites) on the Murray River in the southern Murray–Darling Basin. Annual report cards are available online for the four Victorian icon sites.[1703, 1704] The report cards provide an overall grading as well as individual gradings for the following topics: vegetation, waterbirds, fish and other (e.g. frogs).

The Long-Term Intervention Monitoring Project is a 5-year project managed by the Commonwealth Environmental Water Office (CEWO) that concluded in June 2019. The project assessed the Commonwealth's contribution to environmental water outcomes in various river systems across the Murray-Darling Basin. In Victoria, this project focused on the Goulburn River where Commonwealth environmental water was assessed to have made a important contribution to improved baseflow conditions, which was particularly important in avoiding severe low-flow conditions.[1705]

Following the Long-Term Intervention Monitoring Project, the CEWO has been conducting Flow-MER, which is an on-ground monitoring, evaluation and research program that will run until June 2024 before a future program (referred to as Flow-MER2.0) is scheduled to commence. Flow-MERs objective is to monitor and evaluate the delivery of environmental water in the Murray-Darling Basin. The program aims to provide the CEWO with evidence to inform their understanding of how water for the environment is helping maintain, protect, and restore the ecosystems and native species across the Murray-Darling Basin.[1706, 1707]

Victoria uses results from some of the monitoring programs described above to report on Murray-Darling Basin Plan 'Matter 8' that is required every five years.[1708] The reporting uses VEFMAP, WetMAP, Long-Term Intervention Monitoring, Flow-MER and results from the Living Murray program to demonstrate environmental outcomes for Basin Plan objectives at waterways where water for the environment is delivered in the Victorian component of the Murray-Darling Basin.

Data collected through these monitoring programs is also used for monitoring and reporting on the ecological character of Ramsar wetlands, as per state, national and international requirements. An assessment of the health and status of Ramsar wetlands in Victoria is provided in the 'Biodiversity' chapter of this report.

1699. State Government of Victoria, 'Water Act 1989', Authorised Version No. 138, https://content.legislation.vic.gov.au/sites/default/files/2022-08/89-80aa138%20authorised.pdf Accessed 14 March 2023.
1700. Ibid.
1701. Department of Energy, Environment and Climate Action (DEECA), 'Long-term water resource assessment for southern Victoria', Melbourne, Victoria, https://www.water.vic.gov.au/__data/assets/pdf_file/0025/457126/DELW0146_LTWRA_OverviewReport.pdf Accessed 4 January 2023.
1702. Ibid.
1703. Murray-Darling Basin Authority (MDBA) 2018, 'Icon site condition', https://apo.org.au/sites/default/files/resource-files/2018-05/apo-nid143276.pdf Accessed 27 July 2022.
1704. Murray-Darling Basin Authority (MDBA), 'Progress and outcomes', https://www.mdba.gov.au/climate-and-river-health/water-environment/progress-and-outcomes-improving-system Accessed 29 July 2022.
1705. Hale J, Bond N, Brooks S, Capon S, Grace M, Guarino F, James C, King A, McPhan L, Mynott J, Stewardson M, Thurgate N 2020, 'Murray–Darling Basin long term intervention monitoring project — Basin synthesis report', Report prepared for the Agriculture, Water and the Environment, Commonwealth Environmental Water Office (CEWO) by La Trobe University, Centre for Freshwater Ecosystems, CFE Publication 252. May 2020 59p.
1706. Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Monitoring evaluation and research program (Flow-MER)', https://www.dcceew.gov.au/water/cewo/monitoring/mer-program Accessed 4 January 2023.
1707. Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Future Flow-MER', https://www.dcceew.gov.au/water/cewo/monitoring/future-flow-mer Accessed 4 January 2023.
1708. Murray-Darling Basin Authority (MDBA), 'Basin plan 5-yearly reports 2020', https://www.pc.gov.au/inquiries/completed/basin-plan/report/basin-plan.pdf Accessed 5 January 2023.

Indicator assessments

Refer to 'Guide to the indicator assessments' at the start of Part 3 for the accompanying definitions and legends related to the indicator assessment summary tables.

SoE indicator suite adjustments

State of the environment indicators are the foundational tools for evaluating and communicating the impact our activities have on the environment. The assessments of SoE 2018 indicators provided a scientific baseline of the state of Victoria's environment from which future SoE reports build upon.

However, as new pressures, challenges and data sources emerge, the SoE indicator suite must also evolve to ensure their collective assessments provide a comprehensive account of the condition of Victoria's natural values. The SoE 2023 indicator suite has been adjusted, with some new indicators being introduced and some existing indicators either being disaggregated to improve the focus of assessments, merged to enable inter-connected indicators to be evaluated as a whole, superseded, or modified in terms of the scope, breadth of measures or to align with policy targets. Refer to Appendix C of the Summary Report for a complete account of the changes that have been made to the SoE 2018 indicator suite in this report.

Changes to the indicator suite for this chapter are outlined below.

- The modified SoE 2023 indicator 'WQ:10 Volume of treated and poorly treated discharges to surface waters and compliance with licence requirements' was formed by expanding the measure of the SoE 2018 indicator 'WQ:09 Volume of sewage discharge to surface waters'.
- The modified SoE 2023 indicator 'WQ:11 Percentage of inland water pollution reports requiring a field response by EPA Victoria' was formed by modifying the measure of the SoE 2018 indicator 'WQ:10 Reported inland water pollution incidents'.
- The modified SoE 2023 indicator 'WR:01 Water resources and storage trends' was formed by merging the SoE 2018 indicators 'WR:01 Water resources and storage trends' and 'WR:02 Projected runoff to dams and catchments'.
- The modified SoE 2023 indicator 'WR:02 Interception of surface water by small farm dams' was formed by modifying the measure of the SoE 2018 indicator 'WR:05 Number of dams, weirs and levees' to provide greater focus on the impacts of small dams.
- The modified SoE 2023 indicator 'WR:04 Percentage of compliance with entitlements for the take of surface water' was formed by modifying the measure for the SoE 2018 indicator 'WR:07 Percentage of waterways and groundwater areas subject to extraction, with a limit on extraction'.
- The modified SoE 2023 indicator 'WR:07 Groundwater levels, consumption and use' was formed by merging the SoE 2018 indicators 'WR:12 Groundwater levels' and 'WR:13 Groundwater harvested for consumptive use'.
- The SoE 2018 indicator 'WR:10 Groundwater ecosystems' indicator is now assessed within the 'Biodiversity' chapter (B:04) of this report.

Inland waters — Water quality

Indicator WQ:01 Occurrence of algal blooms

WQ:01 Occurrence of algal blooms

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	↙	🟡	🟡	?	🟡

Data source(s):	DELWP
Measure(s):	Number, frequency, extent and duration of algal blooms

Why this indicator?

Algal blooms occur when there are excess nutrients in waterways. Such blooms can produce toxins that have serious health implications for humans, livestock and native animals. They can also block sunlight, preventing aquatic plants from photosynthesising.

Why this assessment in 2023?

Although blue–green algal blooms do not occur statewide, they do occur in a number of waterways. Reports indicate that blue–green algal blooms are increasing in number, frequency, duration and extent, resulting in a downward trend in the assessment. However, data on the spatial extent and the number of blooms are limited.

Summary of State of the Environment 2018 Report assessment

- Low flows, combined with the availability of nutrients and higher water temperatures, have been identified as likely causes of algal blooms.
- A total of 113 cyanobacteria blooms were reported in water bodies throughout all Victorian regions.

Critical data used for the 2023 assessment

- Data are limited on blue-green algal blooms

2023 assessment

The Curdies River flows into Curdies Inlet at Peterborough, 50 km east of Warrnambool in south-west Victoria. The river catchment has been largely cleared of native vegetation, including 93% of the riverbank vegetation — only about 6% to 7% of the banks are fenced and revegetated.[1709] In April 2022, the river experienced a severe algal bloom and native fish died due to a lack of dissolved oxygen.[1710] The river and inlet are on the East Asian-Australian Flyway, with international migratory wading birds regularly visiting to feed, giving the algal outbreak far wider implications. Nutrients running off local dairy farms, low river flows and warmer weather could have helped trigger the outbreak and blooms are becoming a more frequent occurrence.[1711]

[1709] Murray-Darling Basin Authority (MDBA), 'Basin plan 5-yearly reports 2020', https://www.pc.gov.au/inquiries/completed/basin-plan/report/basin-plan.pdf Accessed 5 January 2023.

[1710] Bissland E 2022, 'Talks begin to save Victoria's Curdies River after blue-green algae fish, but not all hopeful', *ABC South West Victoria*, 11 September 2022, https://www.abc.net.au/news/2022-09-11/curdies-river-victoria-consultative-meeting-blue-green-algae/101318594 Accessed 18 September 2022.

[1711] Ibid.

Inland waters — Water quality

There are many types of algae that are found naturally in rivers, creeks, lakes, wetlands and marine waters. However, high nutrient levels, changes in salinity, low storage levels and warmer weather can lead to excessive growth of algae and algal blooms. Land use and land management, along with geology, soil type and rainfall, can all influence the occurrence of blooms. Blooms can:

- impact the efficacy of drinking water treatment facilities and result in taste and odour issues in drinking water supplies
- produce toxins harmful to people and animals through direct contact with, or ingestion of, water or the consumption of untreated or undertreated water, or from the consumption of affected fish and other seafood
- cause reductions in dissolved oxygen in water bodies during algae decomposition and lead to the death of fish and other aquatic life
- impose economic costs for farming, fishing and tourism sectors.[1712]

Blue-green algal blooms involving Myrocystis spp. and Nodularia spumigena (among other algal species), are the focus of most reporting of algal blooms. However, harmful and nuisance non-algal blooms, involving dinoflagellates and diatoms, are found in marine and estuarine waters.

Major blooms along the Murray and Darling rivers in the 1990s initiated government policy and management responses and an expansion of scientific research. Victoria now has a statewide framework for preventing, responding to, managing and mitigating algal blooms. The Blue Green Algae Circular states that regional coordinators are 'responsible for coordinating the management of local [blue-green algal] blooms, as well as coordinating planning and preparedness for managing regional [blue-green algal] blooms,' while 'local water managers are responsible for managing [blue-green algal] blooms in their local water body.'[1713] Examples of local water managers include CMAs, water corporations, some local councils, DEECA and Parks Victoria.

The Gippsland Lakes and Victorian rivers in the Murray-Darling Basin are where algal blooms frequently occur. Four algal blooms occurred along the Murray River between 2006 and 2016, with the 2016 bloom stretching along 1,450 km and lasting 12 weeks. Until that period, algal blooms had not been seen since 1978. The Goulburn River experienced similar blooms in 2019 and 2020, while the Macalister Irrigation District recorded its first-ever bloom in 2020.[1714]

There were eight algal blooms in the Gippsland Lakes between 1986 and 2013, and most recently in the first half of 2022 which led to recreational alerts for people to avoid water contact activities and the consumption of seafood from the lakes. Table WQ4 presents the March 2022 result of monitoring in the Gippsland Lakes at the height of the 2022 algal bloom.

Monitoring of algal blooms varies. However, it is usually restricted to measuring biovolumes, not necessarily the concentration of toxins in the water body that would be present in the water column after the bloom collapses. Therefore, the duration of the algal bloom impact may not be reported accurately. For example, the Gippsland Lakes algal bloom in 2022 was detected in February 2022 and, despite collapsing in June 2022, seafood sampling monitoring showed that algal toxins in crabs, for example, remained elevated above health guideline values many months after.

An analysis of core samples from the bed of the Gippsland Lakes revealed that algal blooms had occurred there during two main periods in the past 200 years. The first was prior to the opening of the entrance in 1886, a time when the lakes were nutrient rich from low flushing and land clearing. Flushing increased with the permanent opening of the entrance and salinity levels rose. This discouraged algal blooms until after World War II, when land clearing and high-intensity agriculture (and its use of fertilisers) expanded in the catchment and contributed more nutrients to the system.[1715]

1712. Department of Environment Land, Water and Planning (DELWP) 2019, 'Algal bloom response plan', Melbourne, Victoria.
1713. Department of Environment, Land, Water and Planning (DELWP) 2018, 'Victorian blue-green algae circular: algal management framework', Melbourne, Victoria.
1714. HydroNumerics 2020, 'Developing a new framework for future blue-green algae assessment and management, Final report', report prepared for the Department of Environment Land, Water and Planning (DELWP), Docklands Victoria.
1715. Holland D, Jennings M, Beardall J, Gell P, Doan P, Mills K, Briles C, Zawadzki A, Cook P 2013, 'Two hundred years of blue-green algae blooms in the Gippsland Lakes', prepared for the Gippsland Lakes Ministerial Advisory Committee.

Inland waters — Water quality

Although algal blooms have been generally caused by land-use practices in the catchments of affected water bodies, climate change could increase the 'likelihood, frequency of, or amplify the risks posed by algal blooms' by increasing temperatures and changing water inflow patterns.[1716, 1717] The 'Victorian blue-green algae season also appears to be getting longer, with blooms both establishing in and surviving longer through the winter months.' [1718]

In their 2020-21 annual reports, Coliban Water, Goulburn-Murray Water, Lower Murray Water, North East Water, South Gippsland Water and Westernport Water each commented on how blue-green algal blooms are affecting the quality of their water supplies and leading to increased costs of treatment.

Coliban Water is:

> 'noticing an increase in the intensity and duration of blue-green algal blooms across many of our water sources with a changing climate, particularly in the River Murray and associated channels, where there have been significant blooms over the last few years.' [1719]

Lower Murray Water observed that the 'frequency, duration, and concentration of algal blooms within the Murray River appears to have altered in recent years' with an 'increase in the number and length of blue-green algal outbreaks'.[1720] In its 2021-22 annual report, Goulburn-Murray Water said that it had 'issued 21 blue green algae warnings during the year'…'the fourth highest number since records began in 2003.'[1721]

Figure WQ3 provides data on the issuance of recreational warnings for blue-green algal blooms in the Victorian Murray-Darling Basin from 2007 to 2020. The reservoirs have had frequent recreational warnings given, and there has been an increasing trend since 2016. The Loddon is the only river to be subjected to recreational warnings, with other warnings applied to the reservoirs. In the Wimmera, six out of 11 lakes and reservoirs were experiencing algal blooms between 2013 and 2020 (Figure WQ4).[1722] The analysis revealed that water quality in the Goulburn-Murray Water region declines and algal bloom frequency and prevalence increases from east to west. In recent years, Goulburn-Murray Water has reported a rapid increase in observations of algal scum (*Mirocystis* spp.) which are frequently toxic.[1723]

There are currently few economically feasible treatment options for blue-green algae in an environmental or agricultural setting.[1724]

[1716] Department of Environment Land, Water and Planning (DELWP) 2019, 'Algal bloom response plan', East Melbourne, Victoria.
[1717] Ibid.
[1718] Ibid.
[1719] Coliban Water 2021, 'News 4 January 2021' https://coliban.com.au/warm-conditions-impacting-raw-water-quality-murray-system Accessed 3 October 2022.
[1720] Lower Murray Water 2021, 'Lower Murray Water annual report 2020-21', Mildura, Victoria.
[1721] Goulburn-Murray Water 2022, 'Goulburn-Murray Water annual report 2021-22', Tatura, Victoria.
[1722] Department of Environment Land, Water and Planning (DELWP) 2020, 'Water quality in the Victorian Murray-Darling Basin. A basin plan report: Matter 12 progress towards targets of Chapter 9, 2020', Melbourne, Victoria.
[1723] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.
[1724] Ibid.

Inland waters — Water quality

Table WQ4: Blue-green algal bloom test results for the Gippsland Lakes during March 2022.[1725]

Location	Species	Algae levels	Potential toxin producer	Recreational alert	Seafood advisory
Hollands Landing	*Microcystis*	Moderate	Yes	Yes	No contact with water at Marlay Point, Hollands Landing, Roseneathe Caravan Park and Duck Arm.
Marlay Point	*Microcystis*	Moderate	Yes	Yes	
Roseneathe Caravan Park	*Microcystis*	High	Yes	Yes	
Wattle Point	*Nodularia spumigena*	Moderate	Yes	No	
Duck Arm, Paynesville	*Nodularia spumigena*	High	Yes	Yes	No consumption of shellfish and crustaceans, including mussels, prawns and crabs for the entire lakes system and Gut and Gill fin fish caught anywhere within the Gippsland Lakes.
Eagle Point	*Nodularia spumigena*	Moderate	Yes	No	
Progress Jetty, Paynesville	*Nodularia spumigena*	Moderate	Yes	No	
Lake King Jetty, Metung	*Aphanizomenonaceae*	Low	Yes	No	
Chinaman's Creek	*Oscillatoriales*	Low	Yes	No	

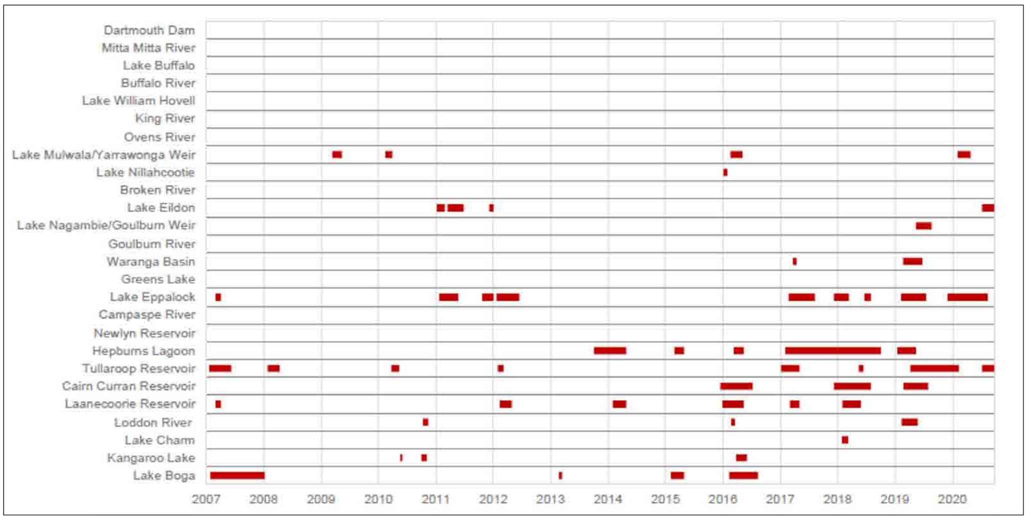


Figure WQ3: Period of recreational use warnings at major recreational waters from blue-green algal blooms in north-east and central north Victoria between 2007 and 2020.[1726]

1725. Department of Environment Land, Water and Planning (DELWP), 'Blue-green algae' https://www.water.vic.gov.au/waterways-and-catchments/rivers-estuaries-and-waterways/blue-green-algae Accessed 18 April 2023.

1726. Department of Environment Land, Water and Planning (DELWP) 2020, 'Water quality in the Victorian Murray-Darling Basin. A basin plan report: Matter 12 progress towards targets of Chapter 9, 2020', Melbourne, Victoria.

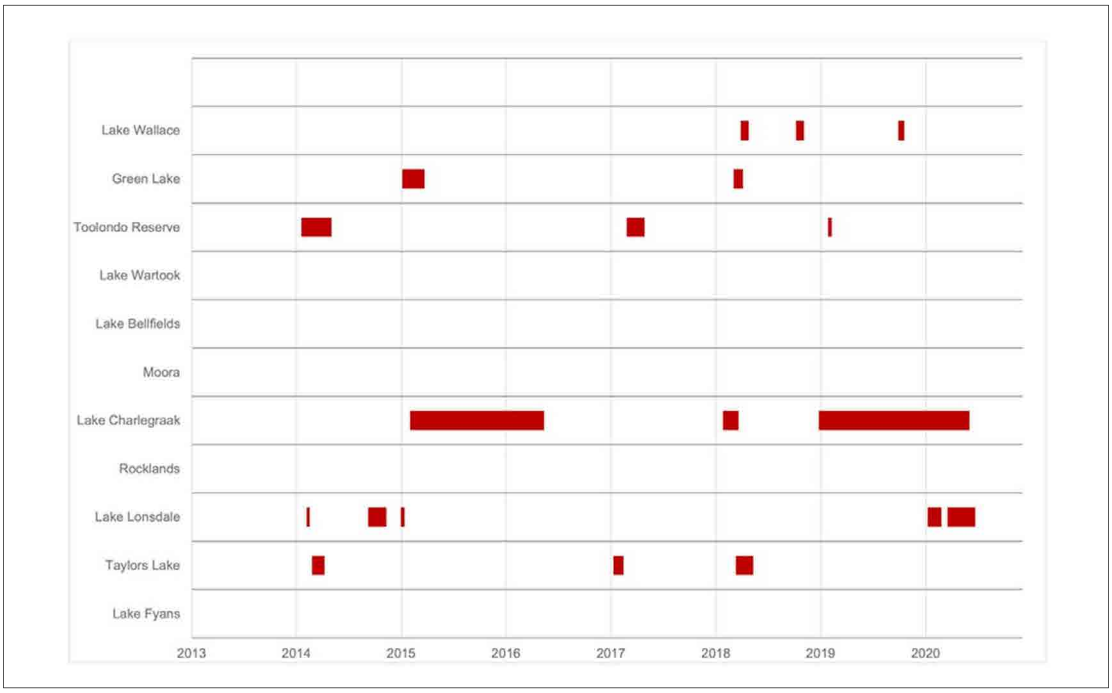
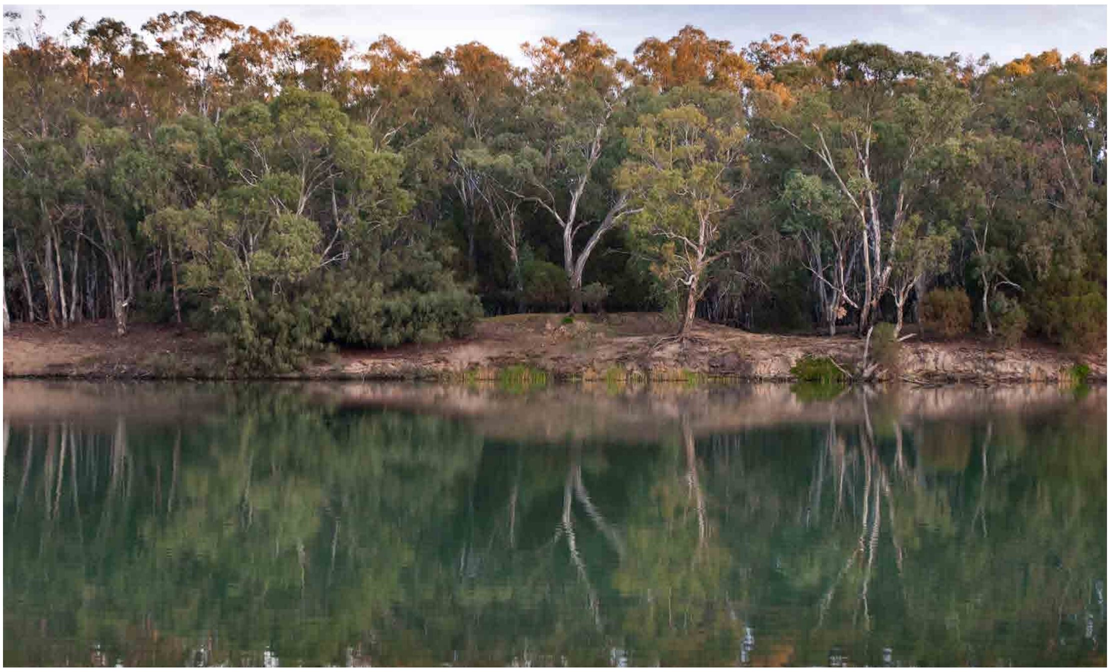


Figure WQ4: Period of recreational use warnings at major recreational waters from blue-green algal blooms in the Wimmera between 2013 and 2020.[1727]



River Murray Reserve 2009.
Credit: Christian Pearson. © Parks Victoria.

[1727] Department of Environment Land, Water and Planning (DELWP) 2020, 'Water quality in the Victorian Murray-Darling Basin. A basin plan report: Matter 12 progress towards targets of Chapter 9, 2020', Melbourne, Victoria.

Inland waters — Water quality

Indicator WQ:02 Dissolved oxygen concentrations in rivers

WQ:02 Dissolved oxygen concentrations in rivers

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
CMAs	● (All CMAs)	→	●	● (All CMAs)	→	●
Data source(s):	DELWP					
Measure(s):	Attainment of ERS water quality objectives by CMAs for dissolved oxygen					

Why this indicator?

Animals that access oxygen in the water column, such as fish, tadpoles and macroinvertebrates, are highly susceptible to decreases in dissolved oxygen. In some cases, large numbers of fish can die in what are called 'fish kills'.

Criteria used for status assessment

Good: CMAs were rated as good or excellent in attaining ERS water quality objectives for dissolved oxygen

Fair: CMAs were rated as moderate in attaining ERS water quality objectives for dissolved oxygen

Poor: CMAs were rated as poor or very poor in attaining ERS water quality objectives for dissolved oxygen

Why this assessment in 2023?

Data from the Water Measurement Information System indicate that all CMA regions attained ERS objectives each year between the periods 2010 to 2017 and 2018 to 2021, with stable trends.

Summary of State of the Environment 2018 Report assessment

- Dissolved oxygen in Victorian rivers and streams for 2010 to 2017 was rated as excellent in the east and central regions of the state, and good in the western CMA regions.
- Longer trends in dissolved oxygen show decreased dissolved oxygen in many river systems during drought years when water receded to residual pools and there was a lack of mixing.
- The only river basin that ranked lower than good was the Murray-Riverina, which includes the main stem of the Murray River, and reflects water quality not only in Victorian rivers, but that flowing in from New South Wales systems into the mid-Murray.

Critical data used for the 2023 assessment

- DEWLP report on water quality indicators and the attainment of ERS water quality objectives in each CMA region for 2010 to 2021
- This is the first major report mapping water quality across Victoria against the new water quality ERS objectives

2023 assessment

Dissolved oxygen in wetlands and waterways is critical to the survival of freshwater fish and aquatic invertebrates. When dissolved oxygen drops suddenly, fish are unable to breathe and 'fish kills' can occur. Excessive amounts of phosphorus and nitrogen entering waterways, from wastewater

Inland waters — Water quality

treatment, runoff from cropland and stormwater, and post-fire runoff can cause algal outbreaks. Dying and decomposing algae consume dissolved oxygen, reducing oxygen available to aquatic life.

The saturation level of dissolved oxygen is a chemical indicator of water quality, along with salinity, nitrogen, phosphorus, turbidity and acidity (pH) which are the subject of assessments later in this theme.

For this report's analysis, a traffic-light system with three assessment rankings is used — good, fair and poor. The SoE rankings are equivalent to the ERS attainment status of good to excellent, moderate, and poor to very poor, respectively.

Figure WQ5 maps the attainment of ERS water quality objectives for dissolved oxygen in each CMA region for 2010 to 2017 and Figure WQ6 maps the chemical indicator for 2018 to 2021. These figures show that, statewide, the attainment of water quality objectives for dissolved oxygen across the two time periods was good.

Figure WQ7 charts the annual percentage attainment of ERS objectives for each CMA between 2018 and 2021 and shows consistently good results across the four years, except for the Wimmera in 2019-21, which was rated as fair in both time periods.

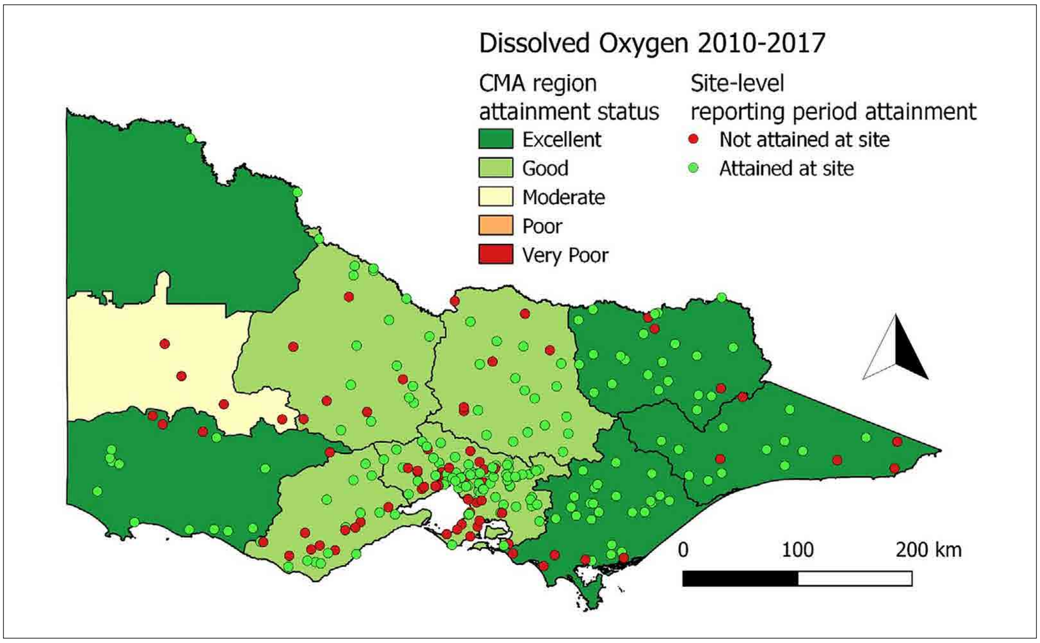


Figure WQ5: ERS attainment for dissolved oxygen between 2010 and 2017 by CMA region and monitoring sites.[1728]

1728. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Inland waters — Water quality

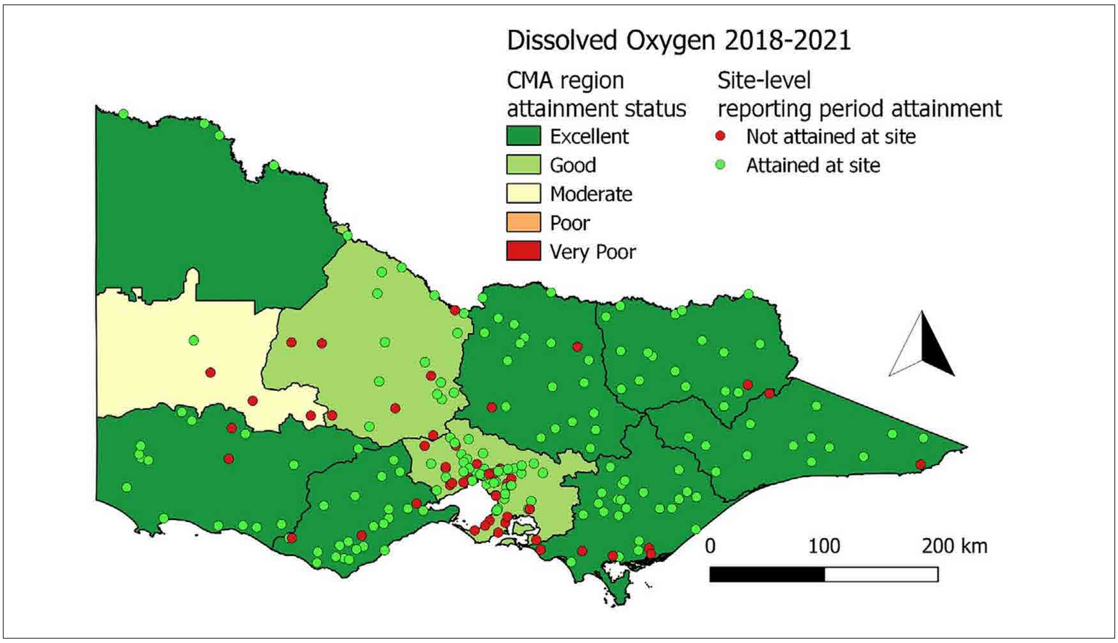


Figure WQ6: ERS attainment for dissolved oxygen between 2018 and 2021 by CMA region and monitoring sites.[1729]

CMA Region	Minimum number of Sites	2018	2019	2020	2021	2018-2021
CORANGAMITE	22	65	73	88	96	81
EAST GIPPSLAND	13	60	75	85	95	80
GLENELG HOPKINS	15	80	88	88	89	87
GOULBURN BROKEN	16	73	88	85	90	84
MALLEE	3	NA	100	100	100	100
NORTH CENTRAL	20	68	80	62	62	68
NORTH EAST	19	90	95	95	100	95
PORT PHILLIP AND WESTERNPORT	56	57	62	70	72	66
WEST GIPPSLAND	28	68	79	93	93	83
WIMMERA	3	80	25	33	25	44

Figure WQ7: Annual ERS attainment from between 2018 and 2021 for dissolved oxygen by percentage of sites per CMA region.[1730]

1729. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.
1730. Ibid.

Inland waters — Water quality

Indicator WQ:03 Salinity concentrations in rivers

WQ:03 Salinity concentrations in rivers

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
CMAs	🟢 (7 CMAs) 🟡 (2 CMAs) 🔴 (1 CMA)	→	🟢	🟢 (7 CMAs) 🟡 (2 CMAs) 🔴 (1 CMA)	→	🟢

Data source(s):	DELWP
Measure(s):	Attainment of ERS water quality objectives by CMAs for salinity

Why this indicator?

Salinity is an important aspect of water quality: changes to salinity levels can have a profound effect on aquatic biota, either through direct toxicity or disruptions to ecosystem processes and functions.

Criteria used for status assessment

Good: CMAs were rated as good or excellent in attaining ERS water quality objectives for salinity

Fair: CMAs were rated as moderate in attaining ERS water quality objectives for salinity

Poor: CMAs were rated as poor or very poor in attaining ERS water quality objectives for salinity

Why this assessment in 2023?

Data from the Water Measurement Information System indicate a good status for most CMAs in attaining ERS water quality objectives for salinity. Trends for each CMA region were also stable between the periods 2010 to 2017 and 2018 to 2021.

Summary of State of the Environment 2018 Report assessment

- Salinity in Victorian rivers and streams for the period 2010 to 2017 was rated as excellent in four catchments and good in a further three.
- The urbanised rivers of the Port Phillip and Westernport catchment were ranked as moderate, with poorer salinity found in the Maribyrnong and Moorabool river basins.
- The far west of the state had lower ratings for salinity, although in the case of the Wimmera catchment, this was based on data from only four sites.

Critical data used for the 2023 assessment

- DEWLP report on water quality indicators and the attainment of ERS water quality objectives in each CMA region for 2010 to 2021
- This is the first major report mapping water quality across Victoria against the new water quality ERS objectives

2023 assessment

Salt naturally occurs in Victoria's rivers and varies across the state. Salt levels in waterways are determined through readings of electrical conductivity in µS/cm. A salinity level of 500 µS/cm would be considered good in East Gippsland, whereas in western Victoria, where natural salt levels are much higher, 1,500 µS/cm is considered good.[1731]

[1731] Department of Environment Land, Water and Planning (DELWP), 'Understanding water quality' https://quality.water.vic.gov.au Accessed 19 September 2022.

Inland waters — Water quality

Aquatic life has evolved to tolerate salt within a certain range. When salinity is elevated beyond that range it can harm aquatic life, as well as degrade soil, damage irrigated crops, reduce the usable supply of water for domestic purposes and increase the cost of water treatment.

Rising concerns about salinity levels in the Murray-Darling Basin during the 1980s led to salinity management strategies agreed to by Victoria, New South Wales and South Australia. In a review of the strategies in the southern Murray-Darling Basin, which in the Victorian section includes the Mallee, Southern Uplands and Riverine Plains bioregions, Hart et al (2020) found that the salinity concerns in the 1980s had been effectively addressed.[1732] However, the authors also flagged that climate change could influence future salinity threats. The main salt reduction actions under the strategies were:

- improvements in irrigation efficiency
- construction of salt interception and drainage diversion infrastructure
- planting of deep-rooted perennials to reduce groundwater recharge
- creation of salinity impact zones to establish new irrigation in areas of low salinity impact.[1733]

For this report's analysis, a traffic-light system with three assessment rankings is used — good, fair and poor. The SoE rankings are equivalent to the ERS attainment status of good to excellent, moderate, and poor to very poor, respectively.

Figure WQ8 maps the attainment of ERS water quality objectives for electrical conductivity in each CMA region for 2010 to 2017 and Figure WQ9 presents ERS attainment for 2018 to 2021. The figures show that, statewide, the attainment patterns for electrical conductivity across the two time periods were the same. CMA regions in the north maintained good attainment in both periods, as did East Gippsland, Corangamite and the Wimmera, while the Port Phillip and Westernport and West Gippsland regions were only fair and Glenelg Hopkins poor.

Figure WQ10 charts the annual percentage attainment of ERS objectives for each CMA between 2018 and 2021 and shows a similar pattern across the four years. The low figure for East Gippsland in 2020 could be the result of the 2019-20 bushfires.

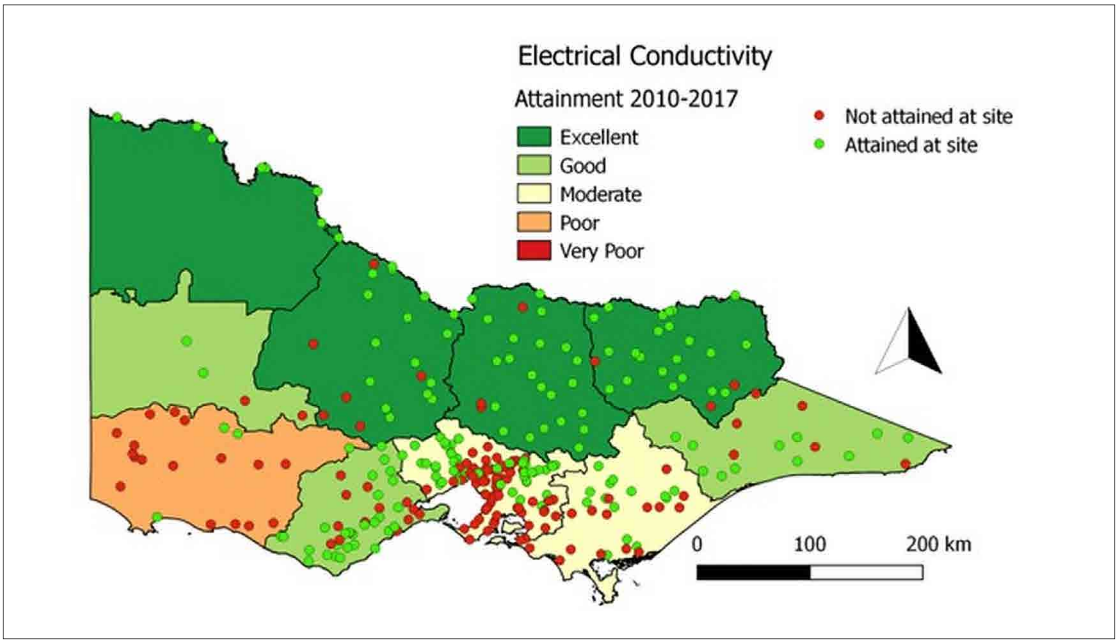


Figure WQ8: ERS attainment for salinity (EC) between 2010 and 17 by CMA region and monitoring sites.[1734]

[1732] Hart B, Walker G, Katupitiya A, Doolan J 2020, 'Salinity management in the Murray-Darling Basin, Australia', *Water* 2020, 12, 1829.

[1733] Ibid.

[1734] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

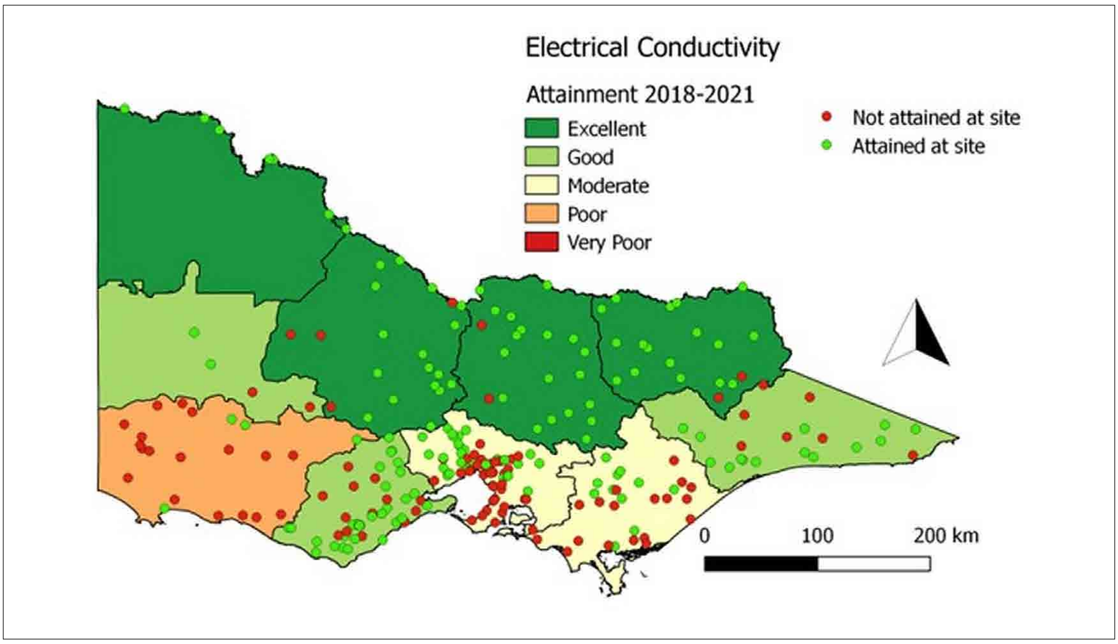


Figure WQ9: ERS attainment for salinity (EC) between 2018 and 2021 by CMA region and monitoring sites.[1735]

CMA Region	Minimum number of Sites	2018	2019	2020	2021	2018-2021
CORANGAMITE	41	61	70	76	74	71
EAST GIPPSLAND	18	61	63	50	68	61
GLENELG HOPKINS	20	20	19	19	24	20
GOULBURN BROKEN	17	80	88	90	86	86
MALLEE	3	100	100	100	100	100
NORTH CENTRAL	20	79	70	85	76	78
NORTH EAST	19	88	84	89	92	89
PORT PHILLIP AND WESTERNPORT	58	47	44	49	46	46
WEST GIPPSLAND	28	38	43	50	43	43
WIMMERA	3	80	50	33	50	56

Figure WQ10: Annual ERS attainment between 2018 and 2021 for salinity (EC) by percentage of sites per CMA region.[1736]

[1735] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.
[1736] Ibid.

Inland waters — Water quality

Indicator WQ:04 Total nitrogen concentrations in rivers

WQ:04 Total nitrogen concentrations in rivers

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
CMAs	🟢 (3-4 CMAs)* 🟡 (3 CMAs) 🔴 (3-2 CMAs)* ● (Mallee CMA)	↗	🟢	🟢 (2 CMAs) 🟡 (2 CMAs) 🔴 (5 CMAs) ● (Mallee CMA)	→	🟢

Data source(s):	DELWP
Measure(s):	Attainment of ERS water quality objectives by CMAs for total nitrogen

Why this indicator?

Nutrients in aquatic ecosystems play a significant role in primary production. Nitrogen and phosphorus are two key nutrients in freshwater systems. However, when too high, they can lead to algal blooms that can be toxic to aquatic animals and plants, livestock and people engaged in water-based activities.

Criteria used for status assessment

Good: CMAs were rated as good or excellent in attaining ERS water quality objectives for total nitrogen

Fair: CMAs were rated as moderate in attaining ERS water quality objectives for total nitrogen

Poor: CMAs were rated as poor or very poor in attaining ERS water quality objectives for total nitrogen

Why this assessment in 2023?

Data from the Water Measurement Information System indicate a mixed status for attainment of ERS water quality objectives by CMAs for total nitrogen. However, there is an improving trend, with an additional CMA having a good status and one fewer having a poor status.

** The first figure presented in brackets refers to the number of CMAs whose status was based on 2010 to 2017 data and the second figure presented in brackets refers to the number of CMAs based on 2018 to 2021 data.*

Summary of State of the Environment 2018 Report assessment

- Attainment of SEPP (Waters of Victoria) objectives for total nitrogen deteriorated from east to west, where Victoria's east was rated as excellent and the state's west poor and very poor.
- Longer-term trends in total nitrogen were influenced by rainfall and flow, with generally increased nutrient loads washing into streams during periods of heavy rainfall and floods.

Critical data used for the 2023 assessment

- DEWLP report on water quality indicators and the attainment of ERS water quality objectives in each CMA region for 2010 to 2021
- This is the first major report mapping water quality across Victoria against the new water quality ERS objectives

Inland waters — Water quality

2023 assessment

Nitrogen is a naturally occurring nutrient in waterways and is critical to the survival of aquatic life. However, when nitrogen becomes excessive it can lead to blue-green algal outbreaks that can cause fish kills, prevent photosynthesis in aquatic plants, restrict recreational activities and potentially poison people who consume seafood harvested in the affected waters.

For this report's analysis, a traffic-light system with three assessment rankings is used — good, fair and poor. The SoE rankings are equivalent to the ERS attainment status of good to excellent, moderate, and poor to very poor, respectively.

Figure WQ11 maps the attainment of ERS water quality objectives for total nitrogen in each CMA region for 2010 to 2017 and Figure WQ12 presents ERS attainment for 2018 to 2021. The figures show that, statewide, there was a clear gradient of change from good ERS attainment in the east to poor in the west. However, the attainment patterns across the two time periods vary. North Central and Goulburn Broken CMAs have improved over the two periods (floods in 2010-11 likely lowered attainment in the first period), whereas the Wimmera has declined. A decline in East Gippsland was likely influenced by the 2019-20 bushfires.

Figure WQ13 charts the annual percentage ERS attainment for total nitrogen in each CMA between 2018 and 2021. It shows a decline in ERS attainment percentages in 2020 and 2021. These were two years of higher rainfall, with a likely increase in sediments flowing into waterways.

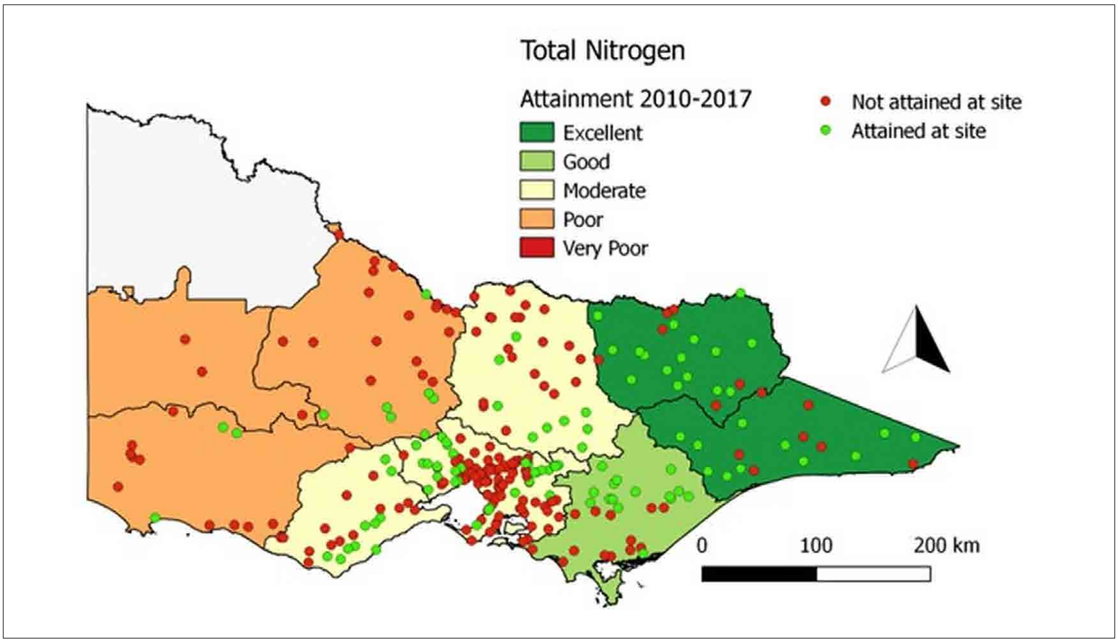


Figure WQ11: ERS attainment for total nitrogen between 2010 and 2017 by CMA region and monitoring sites.[1737]

1737. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

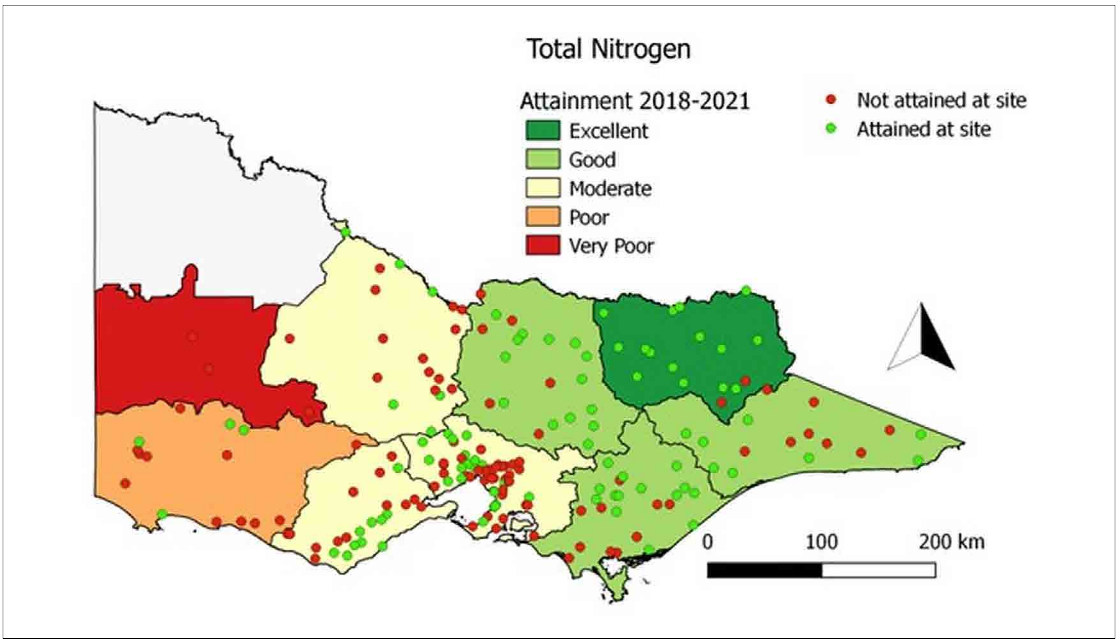


Figure WQ12: ERS attainment for total nitrogen between 2018 and 2021 by CMA region and monitoring sites.[1738]

CMA Region	Minimum number of Sites	2018	2019	2020	2021	2018-2021
CORANGAMITE	21	38	48	61	42	47
EAST GIPPSLAND	14	88	81	29	59	65
GLENELG HOPKINS	14	21	33	13	33	25
GOULBURN BROKEN	16	63	81	26	70	59
MALLEE	0	NA	NA	NA	NA	NA
NORTH CENTRAL	15	42	27	39	44	39
NORTH EAST	17	91	88	76	87	86
PORT PHILLIP AND WESTERNPORT	46	59	41	32	32	40
WEST GIPPSLAND	24	58	58	54	46	54
WIMMERA	3	25	0	0	0	8

Figure WQ13: Annual ERS attainment between 2018 and 2021 for total nitrogen by percentage of sites per CMA region.[1739]

[1738] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

[1739] Ibid.

Inland waters — Water quality

Indicator WQ:05 Total phosphorus concentrations in rivers

WQ:05 Total phosphorus concentrations in rivers

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
CMAs	🟢 (2–4 CMAs)* 🟡 (4 CMAs) 🔴 (3–1 CMAs)* ⚪ (Mallee CMA)	↗	🟢	🟢 (1 CMA) 🟡 (2 CMAs) 🔴 (6 CMAs) ⚪ (Mallee CMA)	→	🟢

Data source(s):	DELWP
Measure(s):	Attainment of ERS water quality objectives by CMAs for total phosphorus

Why this indicator?

Land-use change can lead to run-off containing eroded soil, fertilisers and animal waste that include phosphorus. It can also enter waterways at point-source discharges of treated sewage and stormwater. Increased phosphorus levels in Victoria's waterways can cause algal blooms, which impact fish and other aquatic life.

Criteria used for status assessment

Good: CMAs were rated as good or excellent in attaining ERS water quality objectives for phosphorus

Fair: CMAs were rated as moderate in attaining ERS water quality objectives for phosphorus

Poor: CMAs were rated as poor or very poor in attaining ERS water quality objectives for phosphorus

Why this assessment in 2023?

Data from the Water Measurement Information System indicate a mixed status for attainment of ERS water quality objectives by CMAs for total phosphorus. However, there is an improving trend, with two additional CMAs having a good status and two fewer having a poor status.

** The first figure presented in brackets refers to the number of CMAs whose status was based on 2010 to 2017 data and the second figure presented in brackets refers to the number of CMAs based on 2018 to 2021 data.*

Summary of State of the Environment 2018 Report assessment

- Attainment of SEPP (Waters of Victoria) objectives for total phosphorus deteriorated from east to west, where the far-east of Victoria was ranked as excellent to very poor in the west of the state.
- More than half of the river basins were considered poor or very poor for total phosphorus.
- Longer-term trends in total phosphorus were influenced by rainfall and flow, with generally increased nutrient loads washing into streams during periods of heavy rainfall and floods.

Critical data used for the 2023 assessment

- DEWLP report on water quality indicators and the attainment of ERS water quality objectives in each CMA region for 2010 to 2021
- This is the first major report mapping water quality across Victoria against the new water quality ERS objectives

Inland waters — Water quality

2023 assessment

Phosphorus is a naturally occurring nutrient in waterways and is critical to the survival of aquatic life. However, when phosphorus reaches excessive levels, it can lead to blue-green algal outbreaks that can cause fish kills, prevent photosynthesis in aquatic plants, restrict recreational activities and potentially poison people who consume seafood harvested in the affected waters.

For this report's analysis, a traffic-light system with three assessment rankings is used — good, fair and poor. The SoE rankings are equivalent to the ERS attainment status of good to excellent, moderate, and poor to very poor, respectively.

Figure WQ14 maps the attainment of ERS water quality objectives for total phosphorus in each CMA region for 2010 to 2017 and Figure WQ15 presents ERS attainment for 2018 to 2021. The figures show that, statewide, there was a gradient of change from good ERS attainment in the east and poor in the west, although this is less clear in the 2018 to 2021 period. The attainment patterns across the two time periods differ in several ways. The Glenelg Hopkins, Wimmera, North Central, West Gippsland and North East CMAs have improved over the two periods, whereas there has been a small decline in East Gippsland, likely influenced by the 2019-20 bushfires.

Figure WQ16 charts the annual percentage ERS attainment for total phosphorus in each CMA between 2018 and 2021. It shows a decline in ERS attainment percentages in 2020 and 2021. These were two years of higher rainfall, with a likely increase in sediments flowing into waterways.

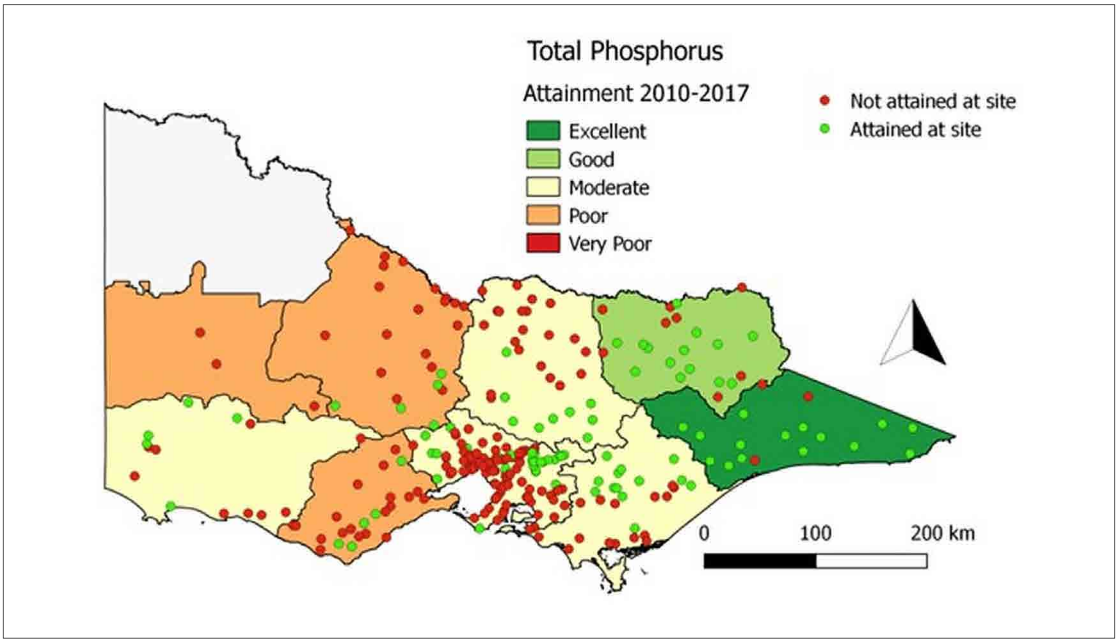


Figure WQ14: ERS attainment for total phosphorus between 2010 and 2017 by CMA region and monitoring sites.[1740]

[1740] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

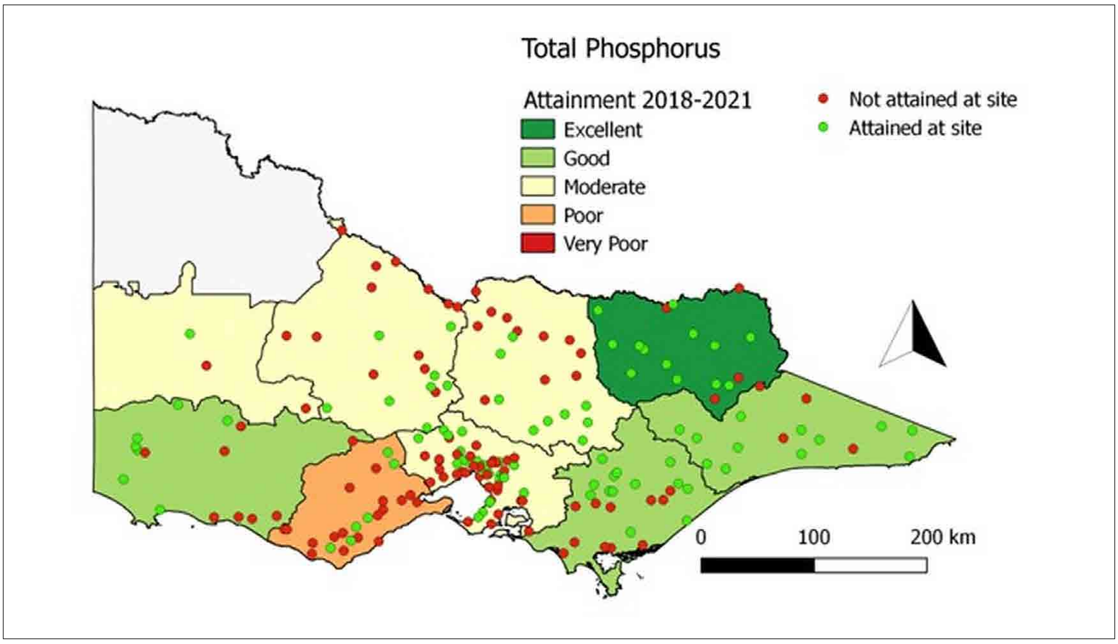
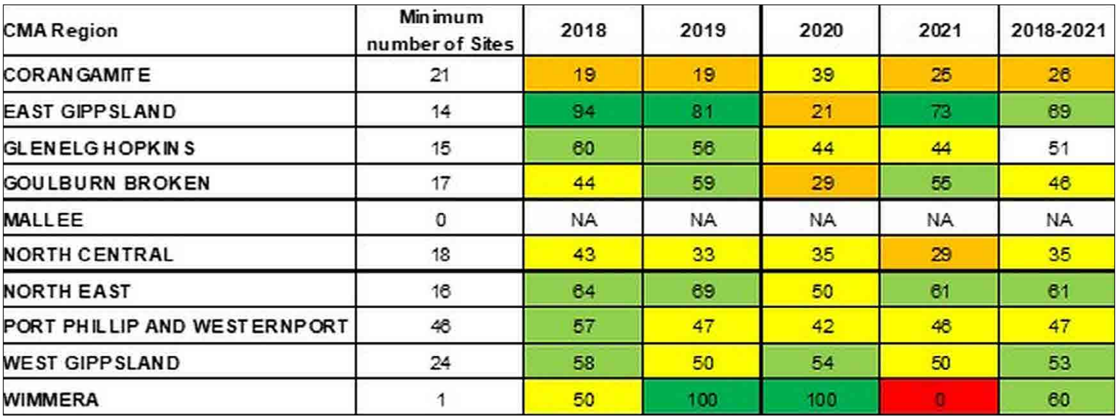


Figure WQ15: ERS attainment for total phosphorus between 2018 and 2021 by CMA region and monitoring sites.[1741]



CMA Region	Minimum number of Sites	2018	2019	2020	2021	2018-2021
CORANGAMITE	21	19	19	39	25	26
EAST GIPPSLAND	14	94	81	21	73	69
GLENELG HOPKINS	15	60	56	44	44	51
GOULBURN BROKEN	17	44	59	29	55	46
MALLEE	0	NA	NA	NA	NA	NA
NORTH CENTRAL	18	43	33	35	29	35
NORTH EAST	16	64	69	50	61	61
PORT PHILLIP AND WESTERNPORT	46	57	47	42	46	47
WEST GIPPSLAND	24	58	50	54	50	53
WIMMERA	1	50	100	100	0	60

Figure WQ16: Annual ERS attainment between 2018 and 2021 for total phosphorus by percentage of sites per CMA region.[1742]

[1741] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.
[1742] Ibid.

Inland waters — Water quality

Indicator WQ:06 Turbidity levels in rivers

WQ:06 Turbidity levels in rivers

Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
CMAs	🟢 (5–10 CMAs)* 🟡 (5–0 CMAs)*	↗	🟢	🟡 (3 CMAs) 🔴 (7 CMAs)	↙	🟢
Data source(s):	DELWP					
Measure(s):	Attainment of ERS water quality objectives by CMAs for turbidity					

Why this indicator?

Turbidity, or water cloudiness, is a measure of the level of suspended sediments in the water column. Elevated turbidity can decrease light penetration in waterways, reduce underwater visibility, clog the gills of fish and macroinvertebrates, and limit photosynthesis in aquatic plants.

Criteria used for status assessment

Good: CMAs were rated as good or excellent in attaining ERS water quality objectives for turbidity

Fair: CMAs were rated as moderate in attaining ERS water quality objectives for turbidity

Poor: CMAs were rated as poor or very poor in attaining ERS water quality objectives for turbidity

Why this assessment in 2023?

Data from the Water Measurement Information System indicate a significantly improved status for attainment of ERS water quality objectives by CMAs for turbidity.

** The first figure presented in brackets refers to the number of CMAs whose status was based on 2010 to 2017 data and the second figure presented in brackets refers to the number of CMAs based on 2018 to 2021 data.*

Summary of State of the Environment 2018 Report assessment

- Turbidity in Victorian rivers and streams from 2010 to 2017 was rated as moderate to very poor.
- Six long-term trend sites all exhibited increasing trends in turbidity related to increased streamflow and rainfall runoff.
- In addition to climate, land use plays an important role in turbidity, with increased land-clearing, agricultural activities that lead to bank erosion and water-resource use all linked to increasing turbidity in Australian streams.

Critical data used for the 2023 assessment

- DEWLP report on water quality indicators and the attainment of ERS water quality objectives in each CMA region for 2010 to 2021
- This is the first major report mapping water quality across Victoria against the new water quality ERS objectives

2023 assessment

Turbidity refers to the level of suspended sediments, such as silt, algae and sewage, in a waterway. It is an indicator of water clarity or cloudiness and is measured in NTUs. The higher the reading, the cloudier the water. Increasing levels of turbidity can clog the gills of fish and reduce photosynthesis in aquatic plants. The suspended sediments could also include toxic metals, such as mercury and lead.

There are various ways that the waterway turbidity can be increased, including sediment flows from cleared and eroding land, catchment runoff after storms and bushfires, discharges of sewage and other wastes, the wallowing of cattle, pigs and deer along riverbanks, and blue-green algal outbreaks.

For this report's analysis, a traffic-light system with three status assessment rankings is used — good, fair and poor. The SoE rankings are equivalent to the ERS attainment status of good to excellent, moderate, and poor to very poor, respectively.

Figure WQ17 maps the attainment of ERS water quality objectives for turbidity in each CMA region for 2010 to 2017 and Figure WQ18 presents ERS attainment for 2018 to 2021. The figures show that there are significant differences across the two time periods for the CMAs. In the 2010 to 2017 period, there were five CMAs — Wimmera, Mallee, North Central, Goulburn Broken and Port Phillip and Westernport —rated as fair. Their rating increased to good for the period between 2018 and 2021, resulting in a good assessment across all CMAs in 2018 to 2021. However, there was a small decline from excellent to good in East Gippsland, likely influenced by the 2019-20 bushfires.

Figure WQ19 charts the annual percentage ERS attainment for turbidity in each CMA between 2018 and 2021. Although there was a decline in ERS attainment percentages for some of the CMAs in the individual years over the period, the average for across the four-year period was rated as either good or excellent. These were two years of higher rainfall, with a likely increase in sediments flowing into waterways.

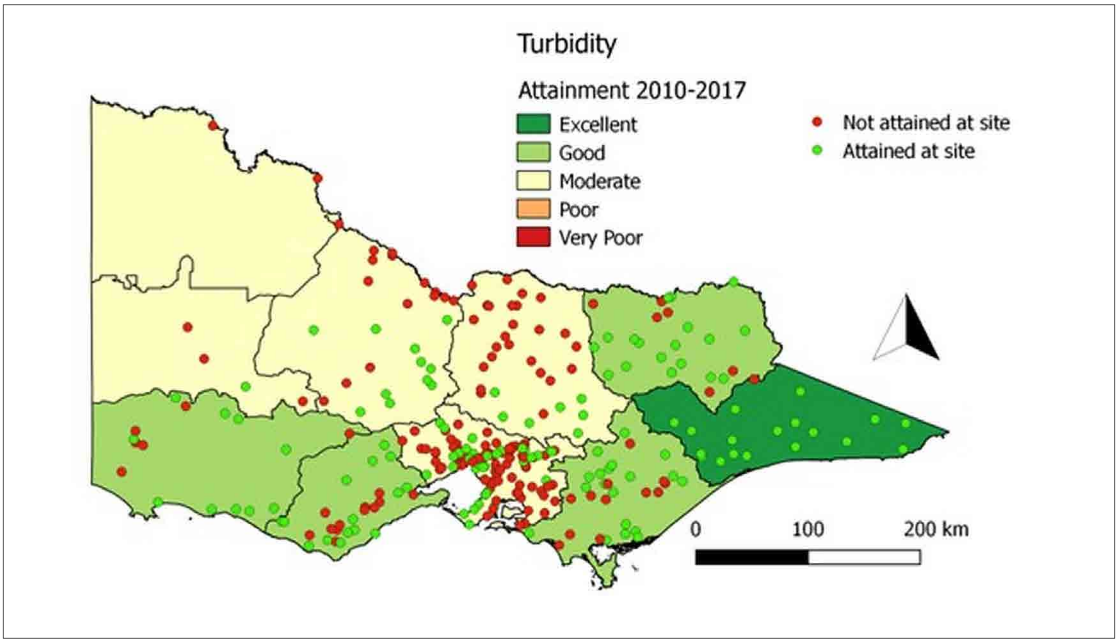


Figure WQ17: ERS attainment for turbidity between 2010 and 2017 by CMA region and monitoring sites.[1743]

1743. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Inland waters — Water quality

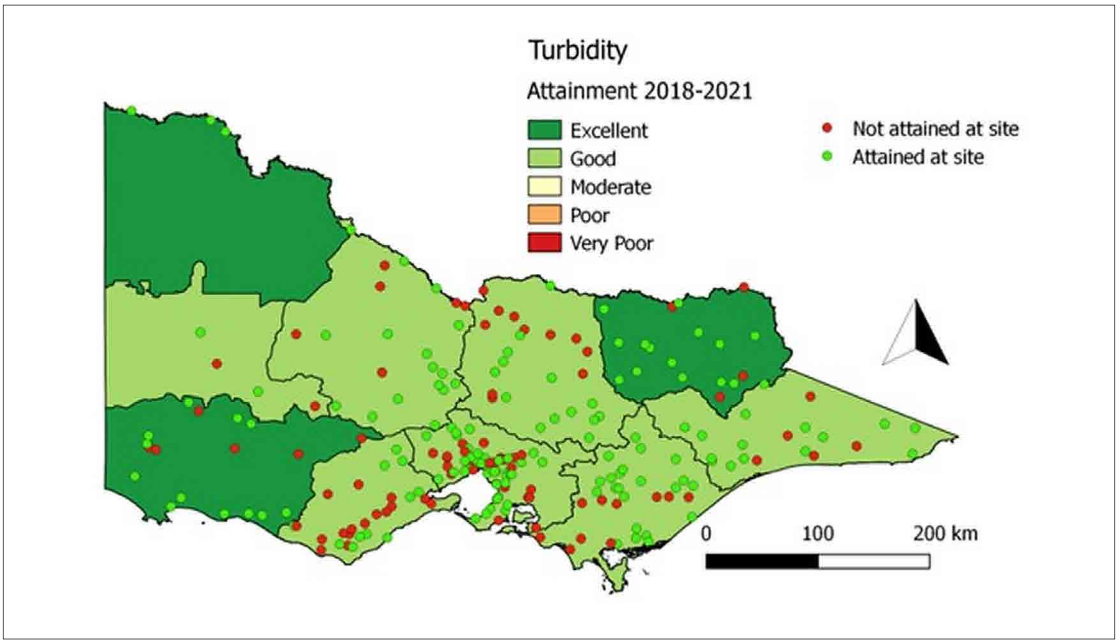


Figure WQ18: ERS attainment for turbidity between 2018 and 2021 by CMA region and monitoring sites.[1744]

CMA Region	Minimum number of Sites	2018	2019	2020	2021	2018-2021
CORANGAMITE	22	72	55	52	29	51
EAST GIPPSLAND	18	95	89	33	52	67
GLENELG HOPKINS	15	73	63	72	74	71
GOULBURN BROKEN	18	48	78	39	54	53
MALLEE	1	100	100	83	33	75
NORTH CENTRAL	20	57	70	55	71	63
NORTH EAST	18	83	83	61	71	75
PORT PHILLIP AND WESTERNPORT	56	82	70	57	57	66
WEST GIPPSLAND	30	73	74	59	57	66
WIMMERA	3	80	50	100	25	63

Figure WQ19: Annual ERS attainment between 2018 and 2021 for turbidity by percentage of sites per CMA region.[1745]

1744. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.
1745. Ibid.

Inland waters — Water quality

Indicator WQ:07 pH levels in rivers

WQ:07 pH levels in rivers

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
CMAs	🟢 (10–7 CMAs)* 🟡 (0–2 CMAs)* 🔴 (1 CMA)	↙	🟢	🟢	→	🟢

Data source(s):	DELWP
Measure(s):	Attainment of ERS water quality objectives by CMAs for pH

Why this indicator?

Aquatic species have a preferred pH range (a measure of acidity). Levels of pH outside those ranges can lead to fish deaths and damage the health of aquatic plants.

Criteria used for status assessment

Good: CMAs were rated as good or excellent in attaining ERS water quality objectives for pH

Fair: CMAs were rated as moderate in attaining ERS water quality objectives for pH

Poor: CMAs were rated as poor or very poor in attaining ERS water quality objectives for pH

Why this assessment in 2023?

Data from the Water Measurement Information System indicate a mixed status for attainment of ERS water quality objectives by CMAs for pH. However, there was a deteriorating trend for three of the CMAs, with two changing from good to fair and one from good to poor.

** The first figure presented in brackets refers to the number of CMAs whose status was based on 2010 to 2017 data and the second figure presented in brackets refers to the number of CMAs based on 2018 to 2021 data.*

Summary of State of the Environment 2018 Report assessment

- Water quality with respect to pH in Victorian rivers and streams for 2010 to 2017 was rated as excellent across all catchment regions and river basins.
- SEPP (Waters of Victoria) water-quality objectives for pH were attained at more than 80% of sites in all catchment regions, except the Port Phillip and Westernport catchment, where 72% of sites recorded attainment.

Critical data used for the 2023 assessment

- DEWLP report on water quality indicators and the attainment of ERS water quality objectives in each CMA region for 2010 to 2021
- This is the first major report mapping water quality across Victoria against the new water quality ERS objectives

Inland waters — Water quality

2023 assessment

The acidity of water is measured as pH, and it increases the further the pH reading falls below seven. The natural levels of pH are the result of the geology and vegetation through which the waterway flows. Aquatic life can tolerate a range of pH values. However, when levels extend beyond their range of tolerance, fish and other aquatic life can be harmed.

Natural levels of pH can change when industrial pollutants, insecticides and fertilisers enter the waterway, where acid sulphate soils are prevalent and when greenhouse emissions, such as CO_2, dissolve in the water. For example, low pH levels were reported in Boundary Creek near Winchelsea in July 2018, likely due to acid sulphate soils in Big Swamp being flushed out by heavy rains.[1746]

For this report's analysis, a traffic-light system with three assessment rankings is used — good, fair and poor. The SoE rankings are equivalent to the ERS attainment status of good to excellent, moderate, and poor to very poor, respectively.

Figure WQ20 maps the attainment of ERS water quality objectives for pH in each CMA region for 2010 to 2017 and Figure WQ21 presents ERS attainment for pH during 2018 to 2021. The figures show that, statewide, there were significant differences across the two time periods. In 2010 to 2017, there were five CMAs — Mallee, North Central, Goulburn Broken and Port Phillip and Westernport — that declined over the two periods, whereas all other CMAs were stable. The decline in attainment in the Mallee could be explained by changes to the monitoring sites used in both periods.

Figure WQ22 charts the annual percentage ERS attainment for pH in each CMA between 2018 and 2021. It shows clear declines in ERS attainment percentages for the Mallee, North Central and Goulburn Broken CMAs.

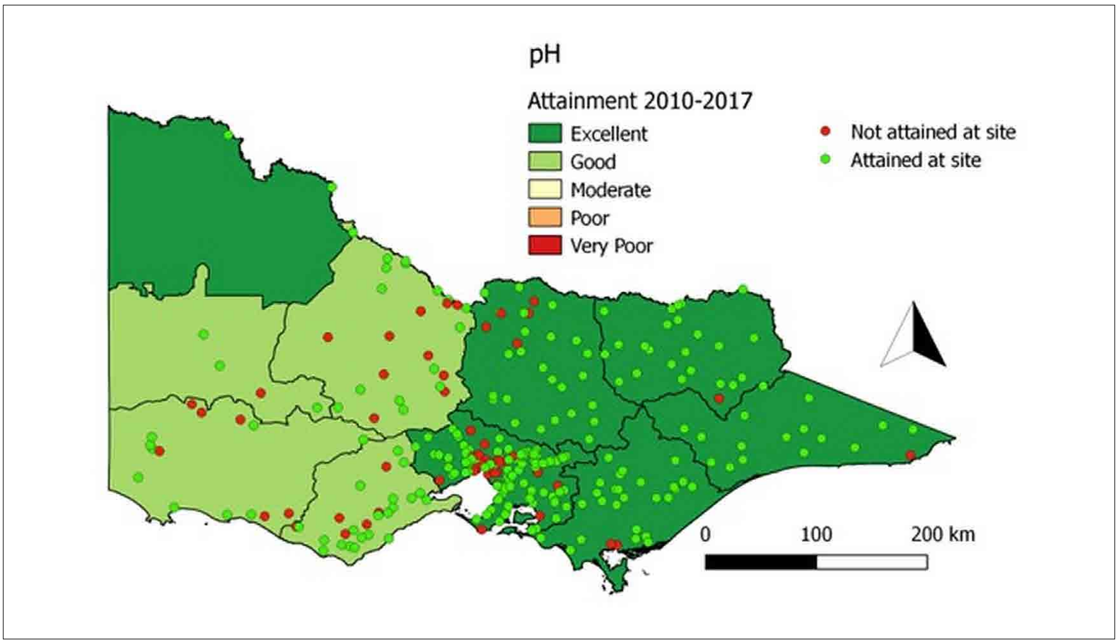


Figure WQ20: ERS attainment for pH between 2010 and 2017 by CMA region and monitoring sites.[1747]

[1746] Taylor J 2018, 'Low pH detected in waterways near Birregurra', *Surf Coast Times*, 4 July 2018.

[1747] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

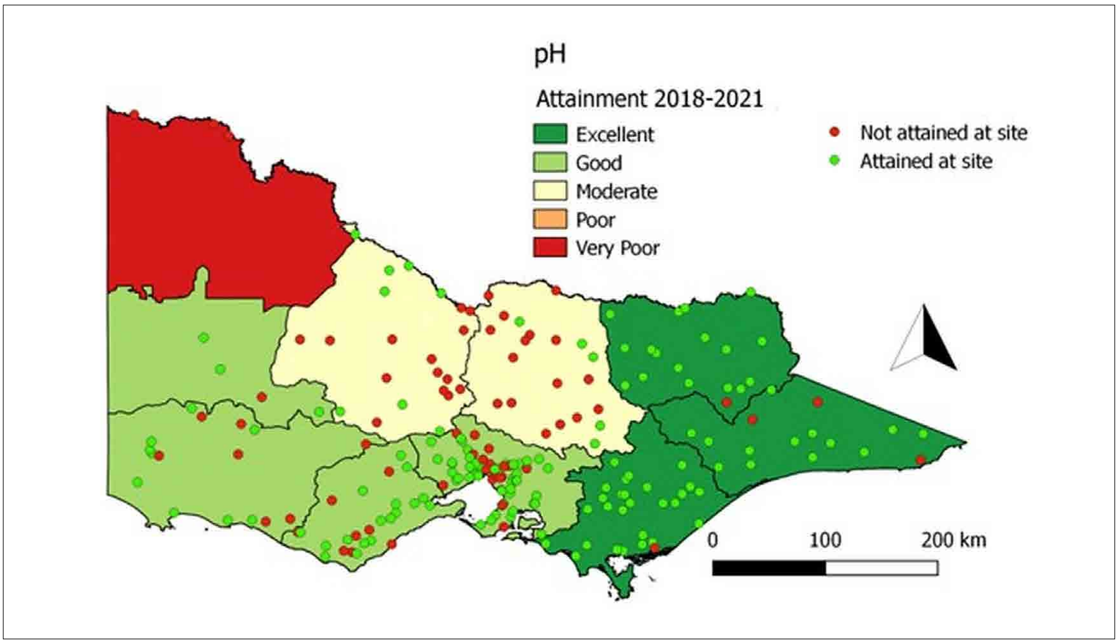


Figure WQ21: ERS attainment for pH between 2018 and 2021 by CMA region and monitoring sites.[1748]

CMA Region	Minimum number of Sites	2018	2019	2020	2021	2018-2021
CORANGAMITE	22	61	59	73	81	69
EAST GIPPSLAND	13	60	67	77	95	76
GLENELG HOPKINS	15	53	50	63	53	55
GOULBURN BROKEN	16	65	25	26	32	39
MALLEE	1	0	0	25	0	10
NORTH CENTRAL	19	67	32	19	70	48
NORTH EAST	18	87	89	94	83	88
PORT PHILLIP AND WESTERNPORT	56	63	62	65	67	64
WEST GIPPSLAND	27	81	79	86	96	86
WIMMERA	3	60	50	67	100	67

Figure WQ22: Annual ERS attainment between 2018 and 2021 for pH by percentage of sites per CMA region.[1749]

[1748] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

[1749] Ibid.

Inland waters — Water quality

Indicator WQ:08 Proportion of water bodies with good ambient water quality

WQ:08 Proportion of water bodies with good ambient water quality

Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
CMAs	🟢 (2–1 CMAs)* 🟡 (3–8 CMAs)* 🔴 (4–0 CMAs)* ● (Mallee CMA)	↗	🟢	🔴	↙	🟢
Data source(s):	DELWP, EPA Victoria, Melbourne Water					
Measure(s):	Attainment of ERS water quality objectives by CMAs in a combined score for indicators WQ:03 to WQ:07					

Why this indicator?

This is one of two indicators for Target 6.3 of UN SDG 6: 'Clean water and sanitation'. The purpose of the indicator is to assess whether efforts to improve water quality are successful.

Criteria used for status assessment

Good: CMAs were rated as good or excellent in attaining ERS water quality objectives for indicators WQ:03 to WQ:07 combined

Fair: CMAs were rated as moderate in attaining ERS water quality objectives for indicators WQ:03 to WQ:07 combined

Poor: CMAs were rated as poor or very poor in attaining ERS water quality objectives for indicators WQ:03 to WQ:07 combined

Why this assessment in 2023?

Based on the combined score for indicators WQ:03 to WQ:07, the status is mixed across the CMAs. There has been an improvement from poor to fair for four CMAs; however, one CMA previously rated good is now rated as fair.

* *The first figure presented in brackets refers to the number of CMAs whose status was based on 2010 to 2017 data and the second figure presented in brackets refers to the number of CMAs based on 2018 to 2021 data.*

Summary of State of the Environment 2018 Report assessment

- The river basins of far-East Gippsland, the Snowy and Mitchell rivers, and the Ovens, Kiewa and Upper Murray regions all had good or excellent water quality. The rest of the state was ranked as fair or poor, with lower water quality in the urbanised river basins of the Port Phillip and Westernport catchment.
- Of the 27 river basins assessed from 2010 to 2017, seven (26%) rated as having good or better water quality. There had been a gradual deterioration of water quality at most (22 of 27) sites between the 2004 to 2009 and 2010 to 2017 monitoring periods.

Critical data used for the 2023 assessment

- DEWLP report on water quality indicators and the attainment of ERS water quality objectives in each CMA region for 2010 to 2021
- This is the first major report mapping water quality across Victoria against the new water quality ERS objectives

Inland waters — Water quality

2023 assessment

In 2015, the UN set 17 SDGs for achievement by 2030. Each of the goals has targets and for each target at least one indicator. SDG 6 is 'Clean water and sanitation' with Target 6.3 being:

> 'By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.' [1750]

The UN defines good ambient water quality 'as ambient water quality that does not damage ecosystem function and human health according to core ambient water quality parameters and is set at the national level.'

One of the indicators for Target 6.3 is Indicator 6.3.2: 'Proportion of water bodies with good ambient water quality.' This indicator is based on five water quality parameters: dissolved oxygen and phosphorus (for surface water only), and salinity, nitrogen and pH (for both surface water and groundwater). Each of these physico-chemical parameters have been assessed separately as indicators earlier in this theme. Water quality can also be measured using biological indicators, such as fish and macroinvertebrates, and hydrology indicators largely focussed on changes in flow.

For this report's analysis, a traffic-light system with three assessment rankings is used — good, fair and poor. The SoE rankings are equivalent to the ERS attainment status of good to excellent, moderate, and poor to very poor, respectively.

Figure WQ23 and Figure WQ24 map the combined scores from the assessments for indicators WQ:03 to WQ:07. They show improvements for the Glenelg Hopkins, Wimmera, North Central and Port Phillip and Westernport regions between the two time periods, and a small decrease in East Gippsland.

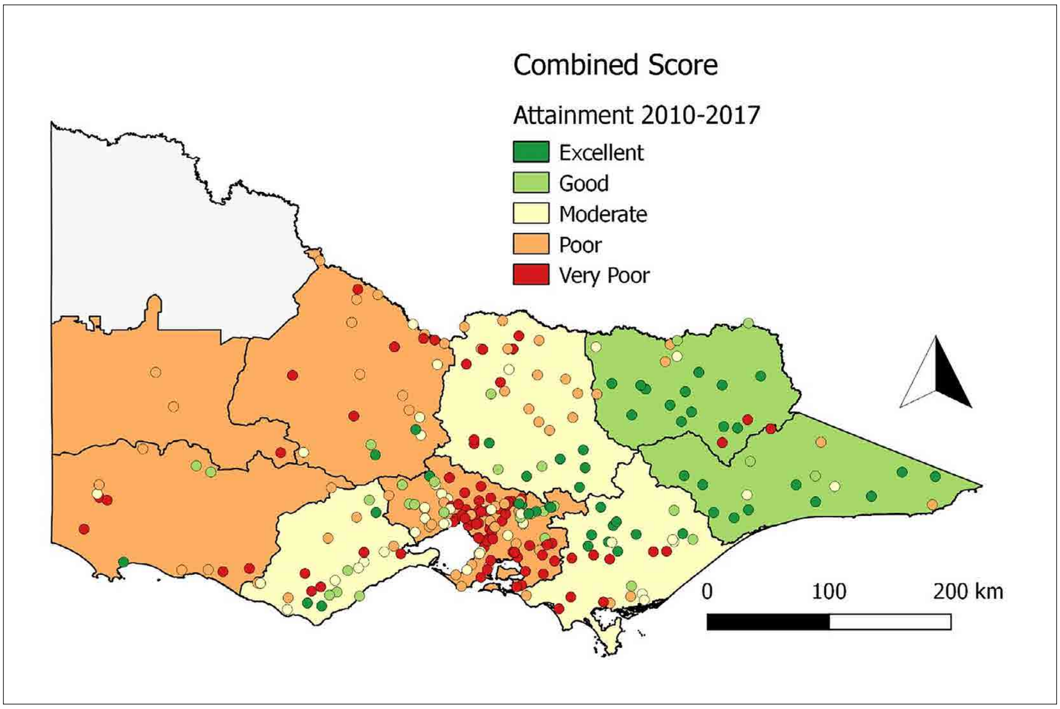


Figure WQ23: Combined score for ERS attainment for indicators WQ:03 to WQ:07 between 2010 and 2017 by CMA regions and monitoring sites.[1751]

[1750] United Nations, 'Indicator 6.3.2' https://www.unep.org/explore-topics/sustainable-development-goals/why-do-sustainable-development-goals-matter/goal-6-0 Accessed 2 October 2022.

[1751] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Inland waters — Water quality

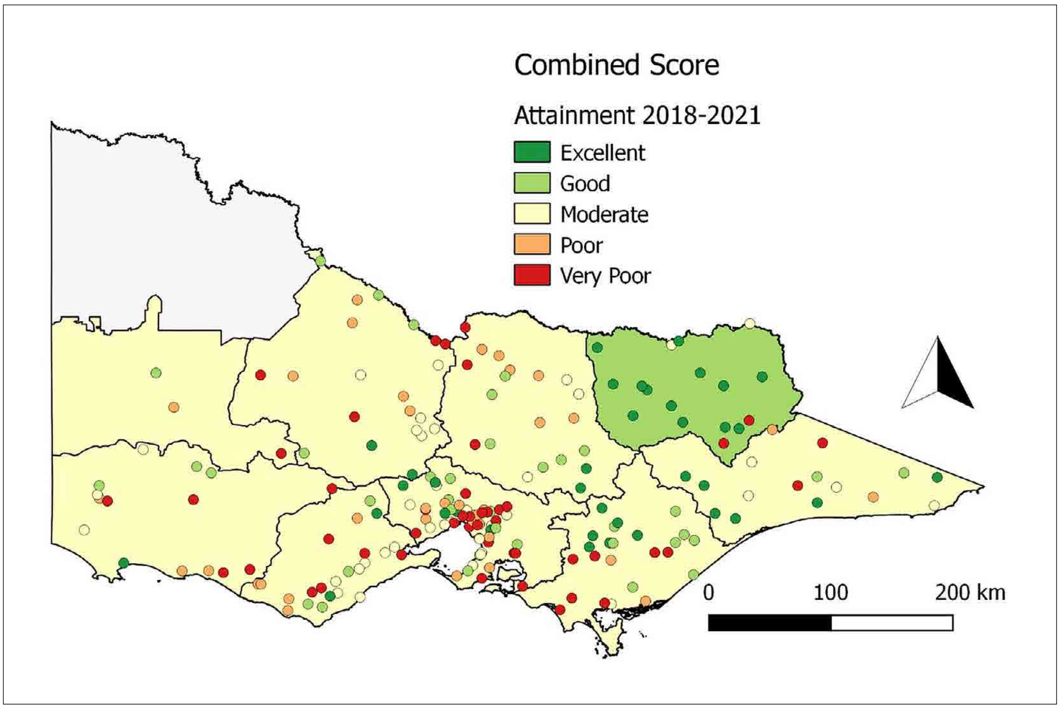


Figure WQ24: Combined score for ERS attainment for indicators WQ:03 to WQ:07 between 2018 and 2021 by CMA region and monitoring sites.[1752]

Water Quality Index for Port Phillip Bay, Westernport and the Gippsland Lakes EPA Victoria, in conjunction with data custodians from Melbourne Water and DELWP, have developed the Report Card to provide an annual assessment of water quality health in Port Phillip Bay, Westernport and the Gippsland Lakes, and the respective surrounding catchments.

The Report Card uses a water quality index (WQI) that is an amalgam of six physico-chemical indicators: dissolved oxygen, metals, nutrients (total nitrogen and phosphorus), pH, salinity and water clarity (turbidity), based around water quality objectives set out in the 2021 ERS.[1753] The scoring system for the index is illustrated in Figure WQ25 for the period July 2020 to June 2021. This is similar to the five-colour traffic-light assessment system used in the maps and charts of the previous indicators in this theme.

The annual report cards on the status of water quality in the catchments of Port Phillip Bay, Western Port, West Gippsland and East Gippsland show that water quality is at its lowest in the urbanised areas and intensively used agricultural land but improving upstream towards the headwaters.

[1752] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022. Environment Protection Authority (EPA) Victoria, 'Report card' https://www.epa.vic.gov.au/for-community/monitoring-your-environment/monitoring-victorias-water-quality/report-card Accessed 11 November 2022.

[1753] Environment Protection Authority (EPA) Victoria 2021, 'Report card 2020-21', Melbourne, Victoria.

Inland waters — Water quality

Water quality index score	Rating	Description
8–10	Very Good	High quality waterbodies generally not impacted by pollution
6–8	Good	Meets Victorian water quality objectives
4–6	Fair	Some evidence of stress
2–4	Poor	Under considerable stress
0–2	Very Poor	Under severe stress

Figure WQ25: WQI scoring categories.[1754]

Figure WQ26, Figure WQ27 and Figure WQ28 map the WQI scores for the Maribyrnong and Yarra rivers, Western Port, West Gippsland and East Gippsland, respectively.

For the Maribyrnong and Yarra rivers, water quality is lowest within the urban area of Melbourne, whereas the headwaters of both rivers return good scores. Western Port's scores are generally poor to very poor, while those in the catchment of the Gippsland Lakes are very good, the exception being the Latrobe River with poor and fair.

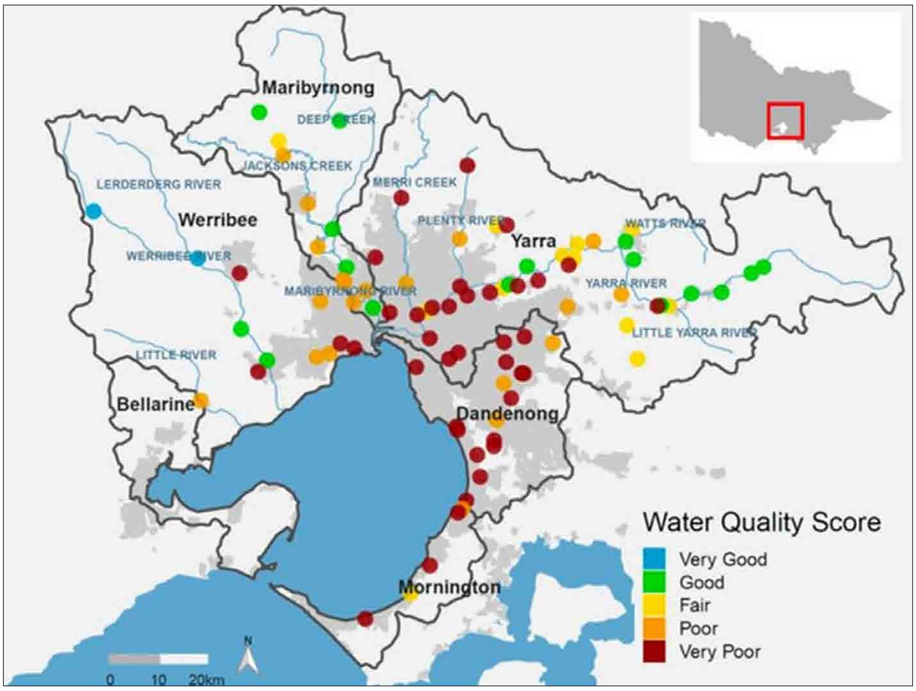


Figure WQ26: WQI scores for the catchments of the Port Phillip Region in 2020.[1755]

[1754] Environment Protection Authority (EPA) Victoria 2021, 'Report card 2020-21', Melbourne, Victoria.
[1755] Ibid.

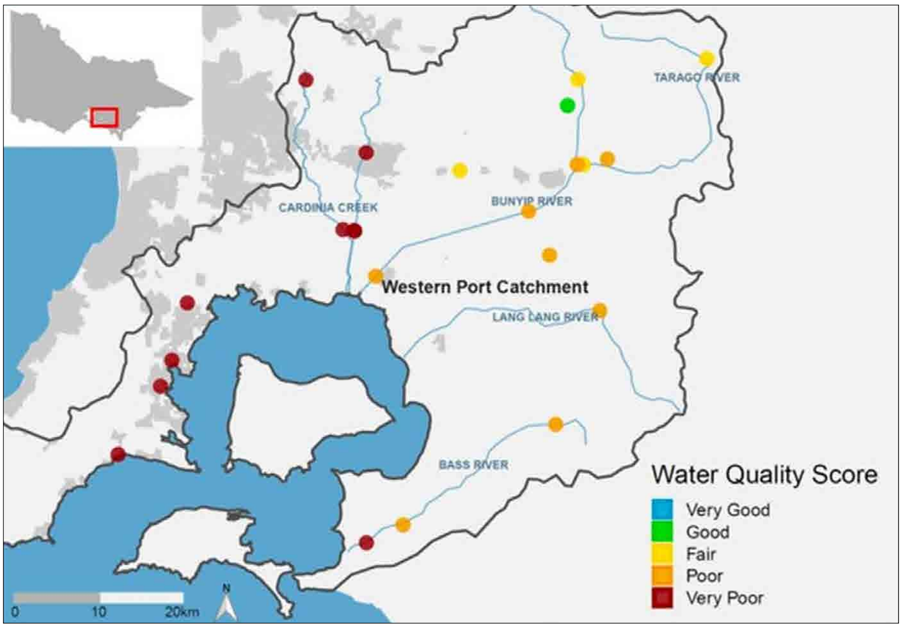


Figure WQ27: WQI scores for the catchments of Western Port in 2020.[1756]

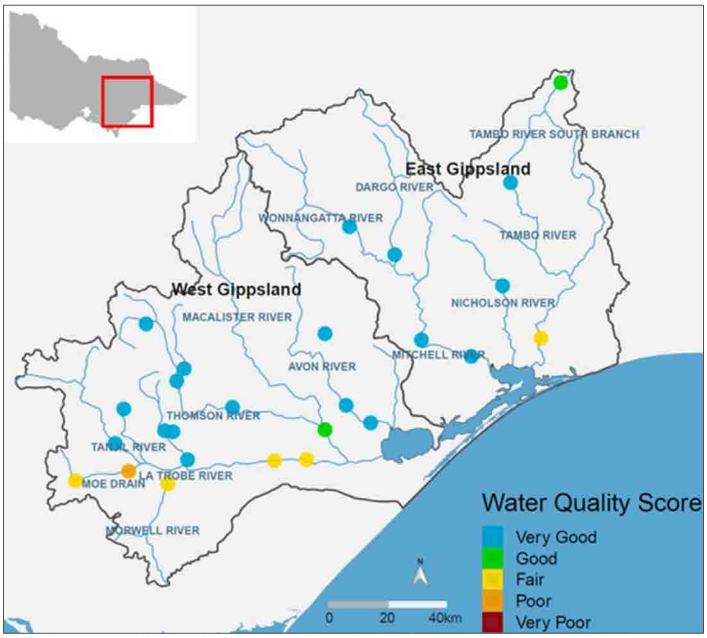


Figure WQ28: WQI scores for catchments of the Gippsland Lakes in 2020.[1757]

Figure WQ29, Figure WQ30 and Figure WQ31 provide trends in WQI scores for each of the three regions from 2000 to 2020. The Yarra has largely scored poor throughout the 10-year period (several years were fair), while the Maribyrnong has largely scored fair (several years were poor and good). In the Western Port catchment, the WQI score remained poor throughout the period, while in East Gippsland and West Gippsland the scores have been good to very good.

[1756] Environment Protection Authority (EPA) Victoria 2021, 'Report card 2020-21', Melbourne, Victoria.

[1757] Ibid.

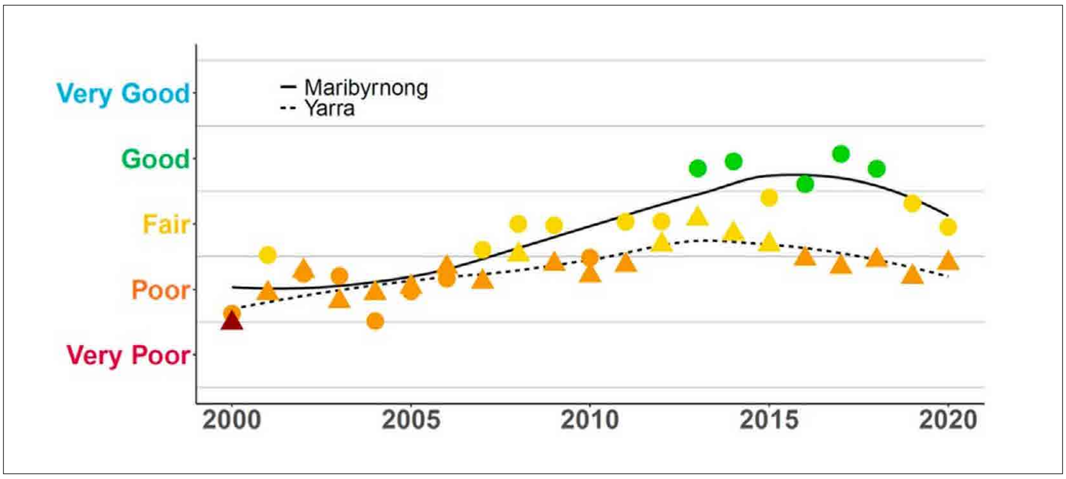


Figure WQ29: WQI scores for the Maribyrnong (circles) and Yarra (triangles) catchments from 2000 to 2020.[1758]

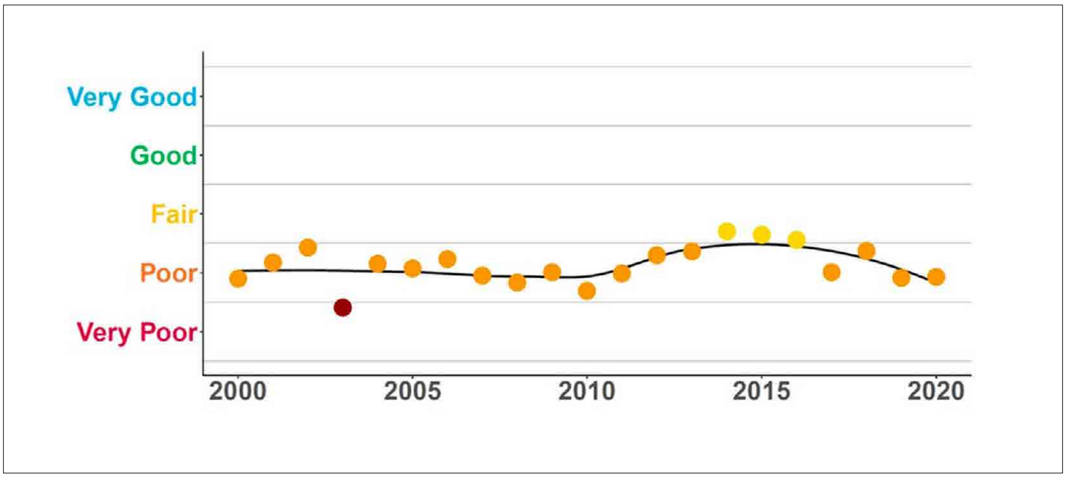


Figure WQ30: WQI scores for the Western Port catchment from 2000 to 2020.[1759]

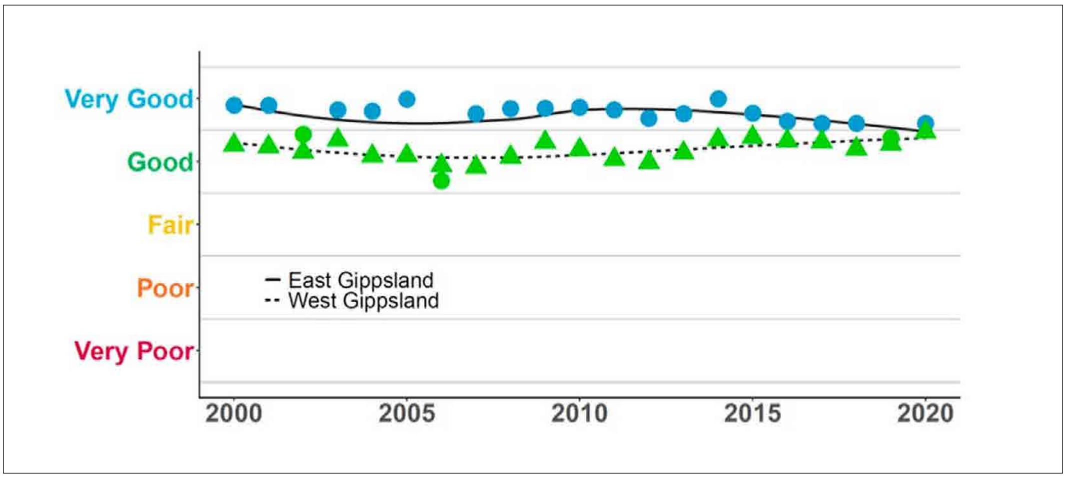


Figure WQ31: WQI scores for East (circles) and West Gippsland (triangles) catchments from 2000 to 2020.[1760]

1758. Environment Protection Authority (EPA) Victoria 2021, 'Report card 2020-21', Melbourne, Victoria.
1759. Ibid.
1760. Ibid.

Inland waters — Water quality

Indicator WQ:09 Groundwater quality

WQ:09 Groundwater quality

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	?	●	🟢 (eastern Victoria) 🔴 (north-western Victoria) 🟡 (elsewhere)	→	🟡

Data source(s):	DELWP
Measure(s):	Electrical conductivity in bore network

Why this indicator?

Groundwater is an important part of Victoria's rural and urban water supply systems and is vital for groundwater-dependent ecosystems.

NB: This indicator was 'WR:11 Groundwater quality' in the SoE 2018 Report.

Why this assessment in 2023?

Data are insufficient to determine either status or trend for this indicator.

Summary of State of the Environment 2018 Report assessment

- Across Victoria, groundwater salinity generally reduces from west to east, with a peak in the north-west of the state and minimums in the alpine region and far-east of the state.
- The long-term trends in groundwater salinity are stable in most observation bores (in areas at risk of rising salinity), meaning that groundwater salinity has remained relatively consistent during the reporting period.

Critical data used for the 2023 assessment

- DELWP maps and data

2023 assessment

Electrical conductivity (salinity) is used to measure the quality of groundwater. Groundwater salinity is largely the result of long-term processes associated with local landscapes and climate, such as geology, drainage, rainfall and evapotranspiration.

Salinity data are collected from private and state observation bores. Sharp changes in water quality (salinity levels) may be the result of human activities, such as extraction, land-use change, land clearance, irrigation, and pollution as well as sea-water intrusion or lateral or vertical movement of saline water within or from other aquifers.

Population growth, competing demands for water and the projected reductions in rainfall and runoff due to climate change are increasing the pressure on surface-water resources. This could lead to an increasing demand for the use of groundwater. The quality of that groundwater will heavily influence its potential uses in the future.

Inland waters — Water quality

Groundwater levels and consumption are assessed in the 'Water resources' theme, which finds that most extracted groundwater is used in agriculture and for urban and rural domestic water supplies. Good quality groundwater for these uses will have low levels of salinity, an indicator of groundwater quality. For some industrial and commercial uses, the level of salinity can be reduced by pre-treatment.

Areas at risk of rising salinity are monitored for groundwater salinity via the groundwater bore network. Figure WQ32 shows that groundwater salinity levels vary across the state, with the highest levels in the north-east, south-west and central areas, and the Gippsland Lakes. Across Victoria, groundwater salinity generally reduces from north-west to south-east, with peaks around Ouyen/Lake Tyrell and minimums in the alpine region and far east of the state. DELWP reported that there has been no significant change in salinity readings over the past five years.

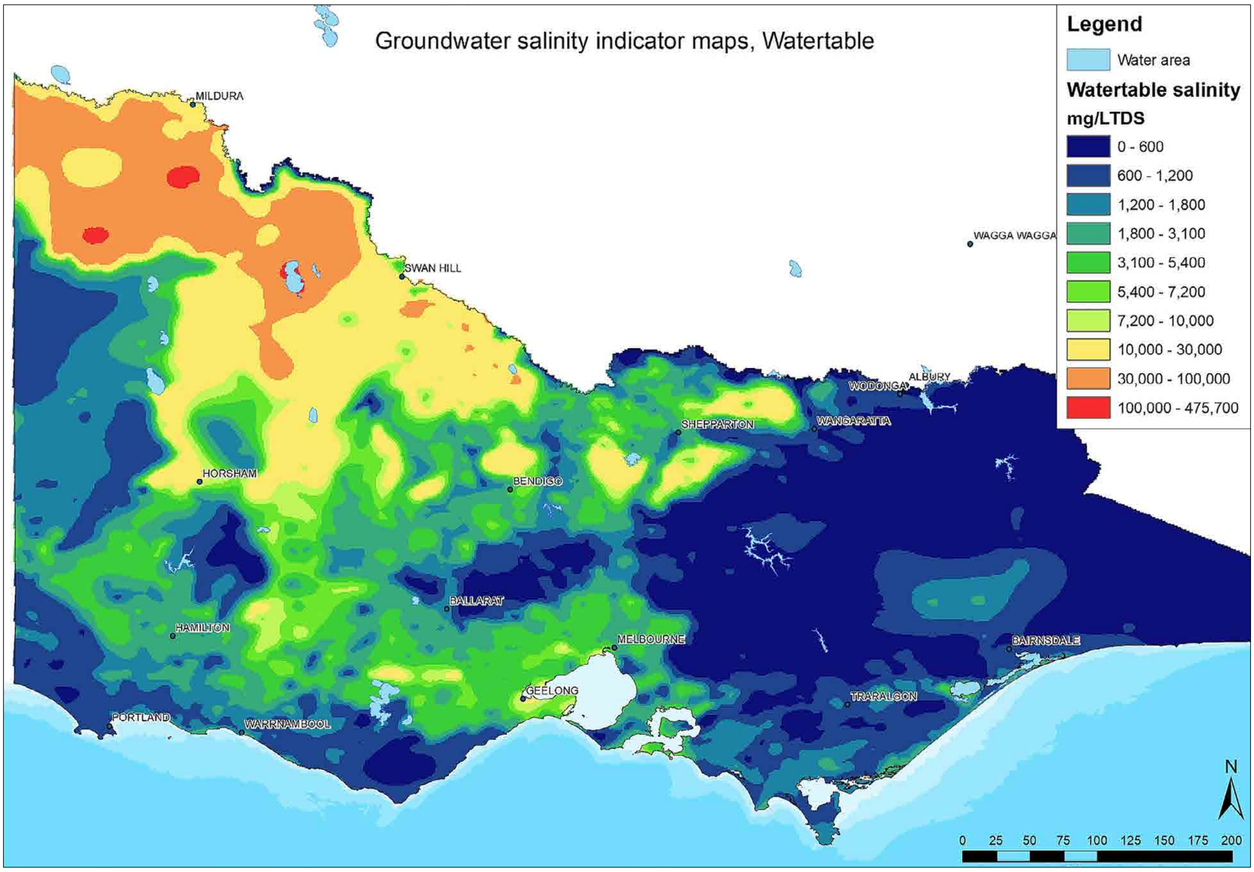


Figure WQ32: Unconfined groundwater salinity levels across Victoria, as at July 2022.[1761]

[1761] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Integrated water management progress report', Melbourne, Victoria.

Inland waters — Water quality

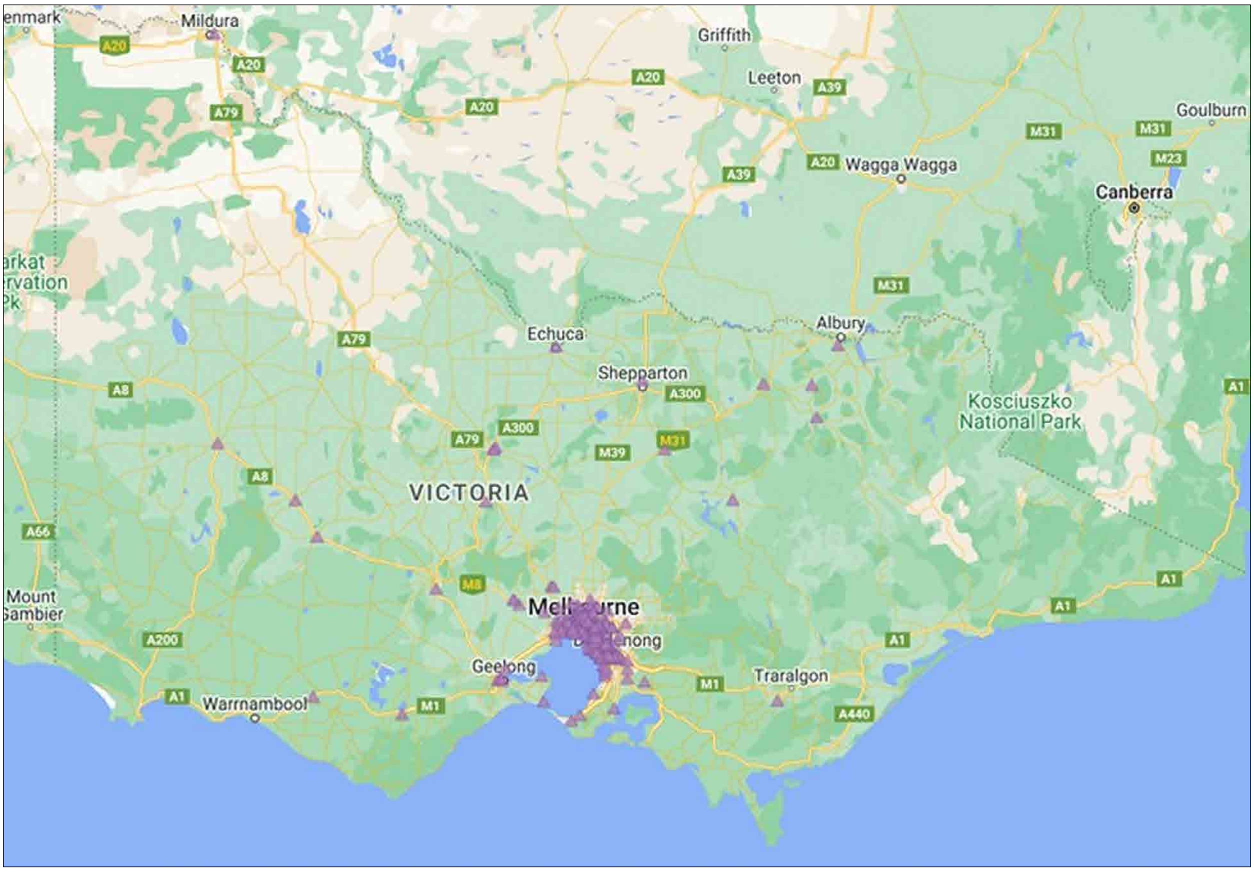


Figure WQ33: GQRUZ (purple triangles) in Victoria, as at July 2022.[1762]

Groundwater may be impacted by pollution from such sources as waste disposal, chemical storage, agricultural chemicals, petrochemicals, nutrients, fertilisers and diffuse sources such as septic tanks and waste-water treatment. Groundwater quality restricted use zones (GQRUZ) cover areas where EPA Victoria environmental audits have shown groundwater pollution remaining and where uses could be limited by poor quality. Figure WQ33 maps GQRUZs across Victoria. There is a major concentration in the Melbourne metropolitan area, while the zones are scattered on the Bellarine and Mornington peninsulas and in the west and north-east of the state.

1762. CeRDI, 'Visualising Victoria's Groundwater' https://www.vvg.org.au/vvg_map.php?agreement=Agree+and+Continue Accessed 22 February 2023.

Inland waters — Water quality

Indicator WQ:10 Volume of treated and poorly treated discharges to surface waters and compliance with licence requirements

WQ:10 Volume of treated and poorly treated discharges to surface waters and compliance with licence requirements

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	?	●	●	?	🔴

Data source(s):	EPA Victoria
Measure(s):	Volume, number and quality of treated and poorly treated discharges Number of licences Compliance with licence requirements

Why this indicator?

Point-source discharges to waterways are the major source of contaminants that are potentially harmful to waterways and to those who use them. For example, animal effluents are a major source of nutrients and pathogens.

NB: This is a modified SoE 2023 indicator that enables a broader assessment to include all licensed discharges and was formed by increasing the breadth of the measures of the SoE 2018 indicator 'WQ:09 Volume of sewage discharge to surface waters'.

Criteria used for status assessment

Good: ≥90% of licensed discharges meet discharge limits

Fair: 65% to <90% of licensed discharges meet discharge limits

Poor: <65% of licensed discharges meet discharge limits

Why this assessment in 2023?

There are insufficient data on discharge volumes and licence compliance to determine status or trend for this indicator.

Summary of State of the Environment 2018 Report assessment

- Regulation of point-source sewage discharges has helped improve the quality of Victoria's water environment over the past 40 years.
- Focus and effort are still needed to maintain and further improve these, particularly given the likelihood of significant changes in the climate.

Critical data used for the 2023 assessment

- Available data are currently limited for the assessment

2023 assessment

In Victoria, high-risk point-source discharges are regulated by EPA Victoria, which specifies minimum acceptable environmental standards for treated effluent discharges to rivers and streams.

Sewage contains pathogens, nutrients, salt, and toxins (e.g. metals and biocides) which can significantly degrade water quality and impact aquatic life and compromise human uses, particularly during dry periods. It enters inland waters from either point sources (e.g. outfall pipes from sewage treatment plants) or diffuse or nonpoint sources (e.g. septic tank discharges where there were several thousand allotments with failing septic tanks in 1995).[1763] Point source discharges of sewage are now managed by Victoria's water corporations under licences from EPA Victoria.

[1763] Environment Protection Authority (EPA) Victoria 1995, 'Managing sewage discharges to inland waters', Melbourne, Victoria, Publication 473, December 1995.

Inland waters — Water quality

Under the EP Act, Environment Protection Regulations and ERS, any businesses that are performing prescribed activities deemed to have a high risk of causing harm to human health or the environment will require a licence to operate. Such operating licences can cover discharges to air, land and water, are categorised according to the source of the waste, and can have standard or site-specific conditions. There are currently 137 operating licences for waste discharges to surface waters in the state and they are categorised by source. Of these 137, the number of licences in each source category were as follows:

- fish farms: 78 operating licences with 21 having site-specific conditions and 57 having standard conditions
- sewage treatment: 23 operating licences with 13 having site-specific conditions and 10 having standard conditions
- industrial wastewater treatment: 9 operating licences with five having site-specific conditions and four having standard conditions
- reportable priority waste management: five operating licences with four having site-specific conditions and one having standard conditions
- extractive industry and mining: five operating licences with all having site-specific conditions
- oil and gas refining: four operating licences with all having site-specific conditions
- power generation: two operating licences with each having site-specific conditions
- Landfills (excluding municipal landfills servicing <5000 people): two operating licences with each having site-specific conditions
- Uncategorised: nine operating licences with six having site-specific conditions and three having standard conditions.[1764]

There are no data available on the compliance levels with the requirements of these licences.

Sediment pond at Fosterville Gold mine.
Credit: Tracey Louise.

[1764] Environment Protection Authority (EPA) Victoria, 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Inland waters — Water quality

Indicator WQ:11 Percentage of inland water pollution reports requiring a field response by EPA Victoria

WQ:11 Percentage of inland water pollution reports requiring a field response by EPA Victoria

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	?	●	NC*	NC	NC

Data source(s):	EPA Victoria
Measure(s):	Percentage of inland water pollution reports requiring a field response EPA Victoria achievement of targets for the pollution performance measure in its Strategic Plan 2022–2037

Why this indicator?

Water pollution can harm animals and plants, harm human health and have other social and economic impacts.

NB: This is a modified SoE 2023 indicator that adopts a new measure that focuses on EPA Victoria's performance in its response to pollution reports from communities, and the severity of the pollution reported. This indicator was formed by modifying the measure of the SoE 2018 indicator 'WQ:10 Reported inland water pollution incidents'.

Criteria used for status assessment

Good: ≥90% of the pollution performance measure target is met

Fair: 65% to 90% of the pollution performance measure target is met

Poor: <65% of the pollution performance measure target is met

Why this assessment in 2023?

Currently there are insufficient data to determine status or trend for this indicator.

** NC indicates that comparisons between the SoE 2018 and SoE 2023 assessments for the modified SoE 2023 indicator would be inappropriate due to the extensive level of variability in the measures and/or data used in the assessment between SoE reports.*

Summary of State of the Environment 2018 Report assessment

- This indicator is a modification of WQ:10 from the SoE 2018 Report by adopting a new measure that focusses on the EPA's performance in its response to pollution reports from the community and the severity of the pollution reported.

Critical data used for the 2023 assessment

- Available data are currently limited for the assessment

2023 assessment

The SoE 2018 Report found that the number of water-pollution reports to EPA Victoria was very stable between 2013 and 2015, then increased by 32% to 1,766 in 2016 before stabilising again in 2017. Three-quarters of the reports were in the Port Phillip and Westernport catchment. For the five years from 2013 to 2017, EPA Victoria received 306 reports of fish deaths, with 39% of fish-death reports originating in the Port Phillip and Westernport catchment.

Table WQ5 summarises the total number of pollution reports and the percentage of those pollution reports in each Victorian region from 2019-20 to 2021-22. In the 3-year period, the number of pollution reports changed very little, increasing from 2,692 in 2019-20 to 2,800 in 2020-21 and then dropping to 2,682 in 2021-22.

Inland waters — Water quality

Between 2016 and 2021-22, the number of pollution reports increased overall by 916, or 52%. However, the percentage of pollution reports in metropolitan regions increased from 66% to 70% and those in non-metropolitan regions dropped from 34% to 30%.

The pollution reports referred to above are those that are made to EPA Victoria by the public. They could reflect greater community awareness of the opportunity to report rather than the level of risk associated with the pollution being reported. In its Strategic Plan 2022-2027, EPA Victoria has set the following performance measure and target on pollution reports: 'Percentage of pollution reports requiring a field response by EPA Victoria due to possible human health and/or environmental impacts.' [1765] This indicator has now been modified to align with the plan's performance measure and target.

The EPA Victoria performance measure covers all pollution reports, not just those about water pollution, and is 'based on a 3-year rolling average of the proportion of pollution reports received by EPA Victoria that are categorised as Priority 3 (planned response), Priority 4 (field response with 24 hours) or Priority 5 (immediate response) triage categories.' [1766] The 2022 baselin has been set at 9%, with a 2024 target of 7.2% and a 2027 target of 4.5%.

Currently there are insufficient data to assess the status or trend of this modified indicator.

Table WQ5: Percentage of pollution reports by region.[1767]

Region	2019-20	2020-21	2021-22
Northern Metro	21%	30%	29%
Southern Metro	19%	19%	22%
Metro*	14%	-	-
Western Metro	12%	16%	19%
South West	11%	13%	11%
Gippsland	9%	9%	9%
North East	6%	6%	3%
North West	6%	6%	4%
Other	2%	1%	3%
Total reports	2692	2800	2682

**Metro was divided into Northern Metro and West Metro for the 2020-21 year and beyond.*

[1765] Environment Protection Authority (EPA) Victoria 2022, 'Strategic Plan 2022-2027', Carlton, Victoria.

[1766] Ibid.

[1767] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Inland waters — Water resources

Indicator WR:01 Water resources and storage trends

WR:01 Water resources and storage trends

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	↙ (long term) ↗ (short term)	🟢	🟡	→	🟢

Data source(s):	DELWP
Measure(s):	Water storage levels in Victoria as a percentage of capacity Projected changes in run-off and inflows

Why this indicator?

The quality and quantity of Victoria's water resources are vital for human health and wellbeing, and for accommodating anticipated population growth. Projected declines in run-off and inflows to water storages have implications for aquatic biodiversity, agriculture and human welfare.

NB: This modified SoE 2023 indicator has been formed by merging the SoE 2018 indicators 'WR:01 Water resources and storage trends' and 'WR:02 Projected runoff to dams and catchments'. The 2018 assessment provided in this report card is for 'WR:01 Water resources and storage trends', as its measure is most comparable to that of the modified 2023 indicator.

Criteria used for status assessment

Good: Over a 10-year period, Victoria's water storage levels are on average at ≥70% storage capacity

Fair: Over a 10-year period, Victoria's water storage levels are on average between 50% to <70% storage capacity

Poor: Over a 10-year period, Victoria's water storage levels are <50% storage capacity

Why this assessment in 2023?

Victoria's water storages and river flows are well monitored, with data publicly reported in the annual Victorian water accounts and the online Current Water Snapshot. Although three wet years since the SoE 2018 Report have seen an upwards trend in water storage levels, the long-term trend is declining.

Summary of State of the Environment 2018 Report assessment

- Victoria's major water storages held nearly 12,500,000 ML. Melbourne's storages accounted for 15% of this capacity, and the state's major regional storages the remaining 85%. Water storages were at approximately 65% capacity.
- Victoria's water storage volumes will be drawn down for longer periods as the state continues to shift to a predominantly drier climate, with more frequent and severe drought conditions. This, together with population growth, will most likely mean that Victoria will draw heavily on water from the Victorian Desalination Plant, and Victorians will have to use water more efficiently.
- Victoria's stream flows were expected to continue declining, in line with projected reductions in cool-season rainfall. Annual runoff was projected to decrease by 5% to 15% across most of Victoria by 2040, and by 10% to 30% by 2065 (relative to the 1975-2014 baseline period), with the largest reductions expected in the south-west.

Critical data used for the 2023 assessment

- Annual Victorian Water Accounts Reports
- Victoria's Water in a Changing Climate 2020
- Current Water Snapshot

Inland waters — Water resources

2023 assessment

Victoria's water resources are connected by pipelines, channels and regulated rivers in an extensive water grid used to collect, store and distribute water around the state. These processes are managed by Melbourne Water and Victoria's water corporations.

Storage capacities and storage levels as a percentage of their capacity (as of 17 March 2023) for the state's major water storages are listed in Table WR6. Three consecutive wet years from 2020 to 2022 have seen storage levels almost reach full capacity.

As of 17 March 2023, Melbourne's water storages were at 92% and regional storages at 86% capacity.

Figure WR34 provides monthly levels for Victoria's major storages from 2010 to 2023. Over the five-year period from 2016-17 to 2021-22, average monthly storage levels were above 75% for only 21 of the 60 months. Figure WR34 reveals a long-term decline in storage levels, although recent conditions are slightly higher than the average during the Millennium Drought from 1998 to 2010.

Table WR6: Victoria's major water storage levels on 17 March 2023.[1768]

Melbourne and regional water storages	Storage capacity (ML)	Storage level (17 March 2023) as a percentage of capacity (%)
Melbourne storages	1,812,185	92.0
Regional storages	-	-
Goulburn-Murray Water		
Dartmouth*	3,856,232	96.7
Hume*	3,005,157	91.6
Eildon	3,334,158	95.9
Eppalock (Total)	304,651	92.8
Cairn Curran	147,150	90.6
Nillahcootie	40,400	87.6
Tullaroop	72,950	91.7
Barwon Water		
Geelong and district	95,435	82.7
Central Highlands Water		
Ballarat and district	60,594	88.5
Coliban Water	-	-
Coliban Southern	69,342	85.0
Gippsland Water		
Moondarra	30,458	94.1
Grampians Wimmera Mallee Water		
Grampians storages	560,311	66.5
South Gippsland Water		
Major systems	6,111	75.5
Southern Rural Water		
Glenmaggie	177,640	53.0
Blue Rock	198,280	95.0
Rosslynne	25,400	97.0
Werribee Basin**	68,995	85.7
Westernport Water		
Candowie	4,458	77.0
All non-Melbourne storages	12,057,722	85.9

**Victoria has a 50% share of inflows to Dartmouth and Hume. Werribee basin storage is the combined volume of the Melton, Merrimu and Pykes reservoirs.*

[1768] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Current water snapshot', https://www.water.vic.gov.au/water-reporting/water-snapshot Accessed 23 February 2023.

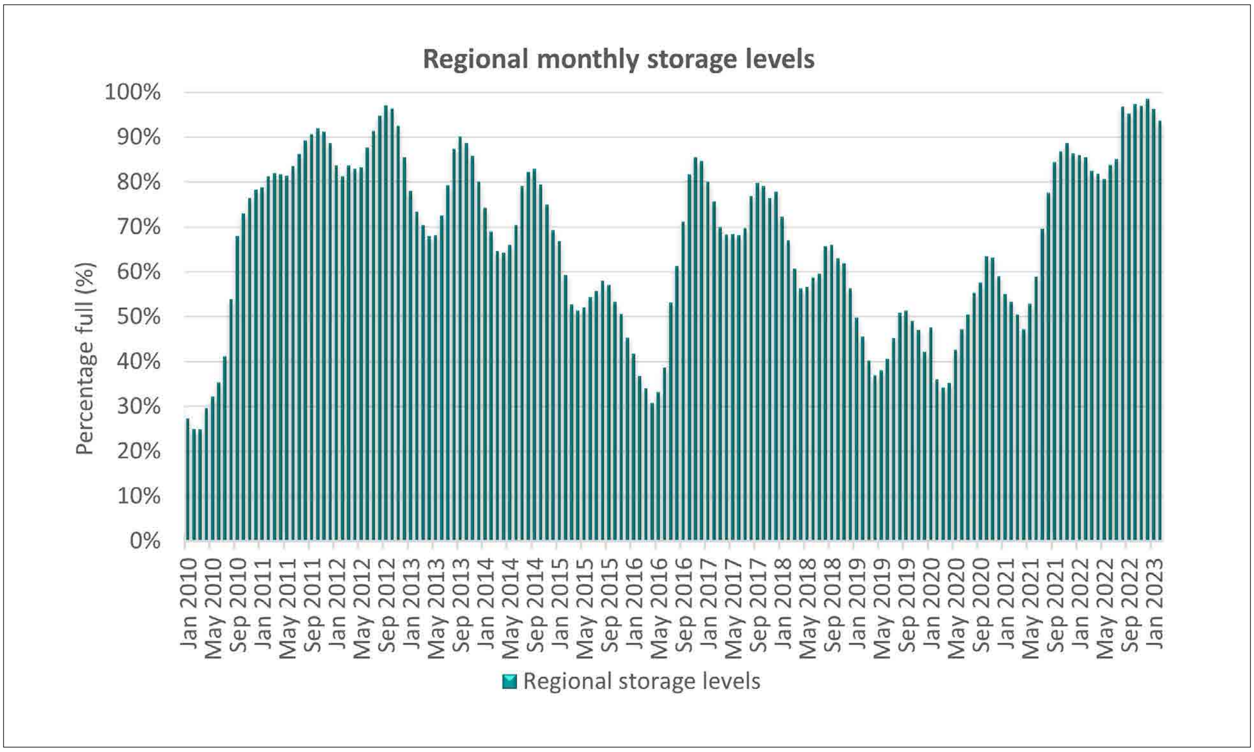


Figure WR34: Volume and levels in Victoria's water storages from 2010 to 2023.[1769]

Storage levels are dependent on the volume of stream flows entering the water storages. Figure WR35 compares annual inflows to Melbourne's main reservoirs from 1914-15 to 2020-21 against the long-term average and shows that they have been declining. The total inflow averaged over the entire period was 570,851 ML, whereas the 30-year average between 1990-91 and 2020-21 was 483,854 ML and the average during the Millennium Drought (1998-2010) was 378,070 ML.

Declining inflows are not unique to Melbourne. Figure WR36 reveals that total Victorian stream flows were well below the long-term average (1975-2019) except for 2010-11 to 2013-14, 2016-17 and 2020-21. However, this is not uniform across the state. Five-year average flows for the years 2016-17 to 2020-21 as a percentage of long-term average annual flows have been calculated for each of Victoria's river basins and reported in Victoria's water accounts.[1770, 1771, 1772, 1773, 1774] Those basins where the 5-year average was between 80% and 100% were Bunyip, Corangamite, Glenelg, Kiewa, Otway Coast, Snowy, South Gippsland, Thomson and the Yarra. Those basins where the 5-year average as a percentage of long-term average annual flows was below 60% were Avoca, Campaspe, Loddon, Maribyrnong and Wimmera. Southern catchments, in general, had higher percentages while northern basins generally had annual inflows below the long-term average.

1769. Department of Energy, Environment and Climate Action (DEECA), 'Current water snapshot', https://www.water.vic.gov.au/water-reporting/water-snapshot Accessed 9 July 2023
1770. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2016-17', Melbourne, Victoria.
1771. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2017-18', Melbourne, Victoria.
1772. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2018-19', Melbourne, Victoria
1773. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian water accounts 2019-20', Melbourne, Victoria.
1774. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.

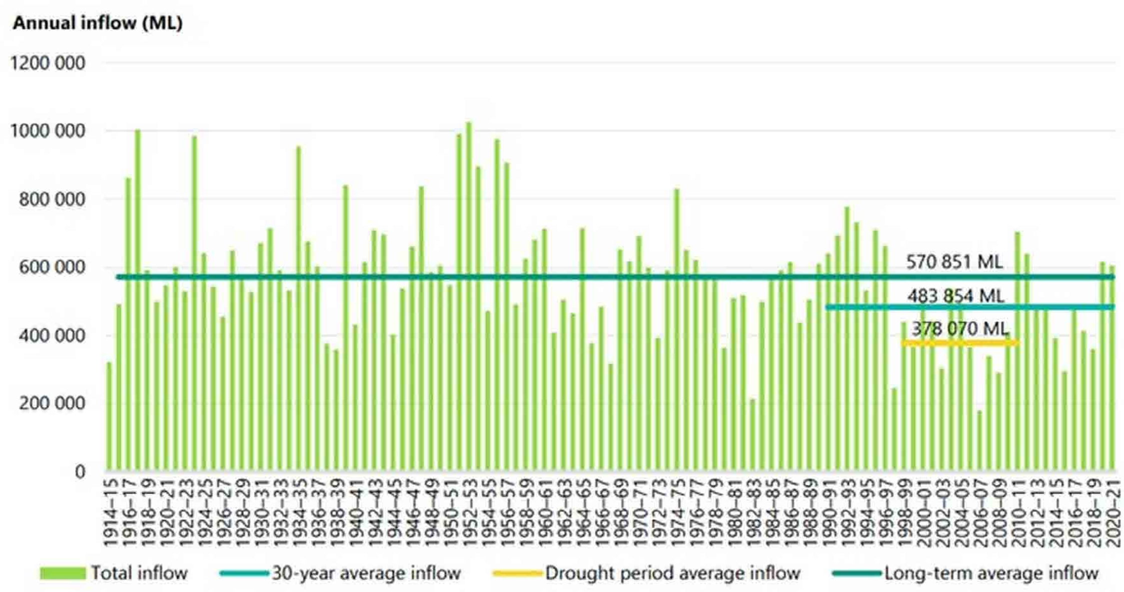


Figure WR35: Annual inflows to Melbourne's main reservoirs from 1914-15 to 2020-21 compared to the long-term average.[1775]

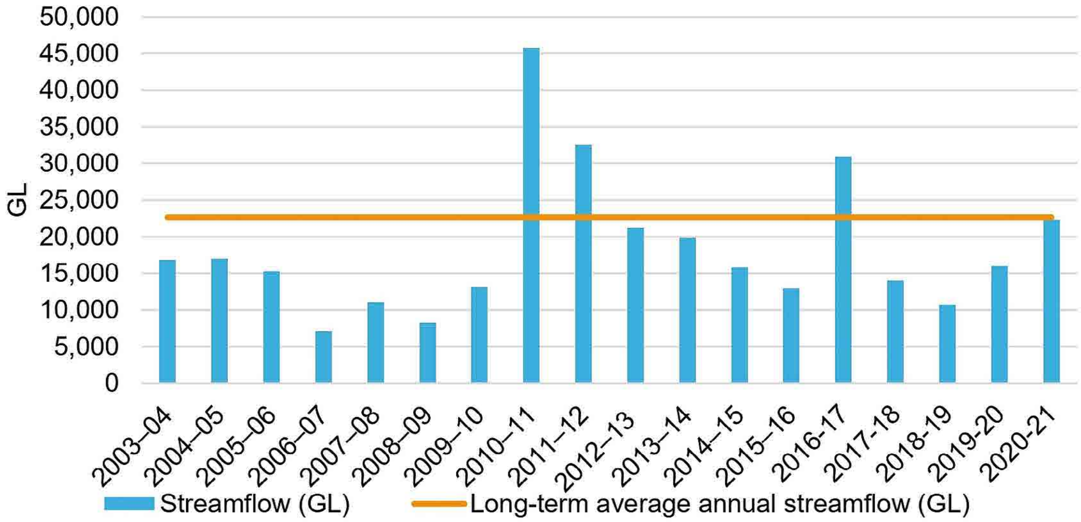


Figure WR36: Total stream flow from 2003-04 to 2020-21 in Victoria compared to the long-term average.[1776]

1775. Victorian Auditor-General's Office (VAGO) 2021, 'Supplying and using recycled water', Melbourne, Victoria.
1776. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.

Inland waters — Water resources

The LTWRA for southern river basins released in 2020 also indicates that stresses on river basins are not uniform across the state, with implications for environmental water flows:

> 'In most basins in the Central region — Barwon, Moorabool, Werribee, Yarra and Latrobe — the decline in long-term surface water availability has not been shared equally: the environment now has a smaller share of the available resource compared to the sustainable water strategy — when water-sharing was last assessed. The environment's proportion would have declined even more had some water not been recovered for the environment (such as by creating new environmental entitlements).' [1777]

A comparison of the variability across Victoria's river basins indicates differing levels of river stress. Figure WR37, Figure WR38, Figure WR39 and Figure WR40 present annual stream flows as volumes and as percentages of long-term averages from 2011-12 to 2020-21 for the Western, Central, Northern and Gippsland basins:

- Western basin: Corangamite, Wimmera, Otway Coast, Hopkins, Portland Coast and Glenelg rivers
- Central basin: Bunyip, Yarra, Maribyrnong, Werribee, Moorabool and Barwon rivers
- Northern basin: Murray, Kiewa, Ovens, Broken, Goulburn, Campaspe, Loddon, Avoca and Snowy rivers
- Gippsland basin: Tambo, Mitchell; East Gippsland, Thomson, Latrobe and South Gippsland rivers.

The blue bars in each of the four graphs represent annual stream flows, while the red line is the annual stream flow as a percentage of the long-term average stream flow. Together, the graphs demonstrate the following:

- The data for the Gippsland basins are less volatile than the Central, Northern and Western basins, likely reflecting more consistent rainfall and forested catchments. In all but two years, the Gippsland basins had percentages of the long-term average stream flow above 80%.
- The northern basins have higher stream flows than the other basins, however their stream flows are gradually declining over the period, except for the major peak in 2016-17. In seven out of the 10 years, their percentage of the long-term average is below 80%.
- The Western basins have the lowest annual stream flows and are more variable from year to year. In 2015-16, they had the lowest annual percentage of the long-term average at 34%. However, in six of the 10 years, that percentage was above 80%.
- The Central basins also have low annual stream flows. However, their patterns are closer to the Gippsland basins than the Western and Northern basins.

Based on these data, the northern and western basins could be described as under greater stress than the Central and Gippsland basins. However, even among those two basins, the levels of stress will vary.

[1777] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Long-term water resource Assessment for southern Victoria', Melbourne, Victoria.

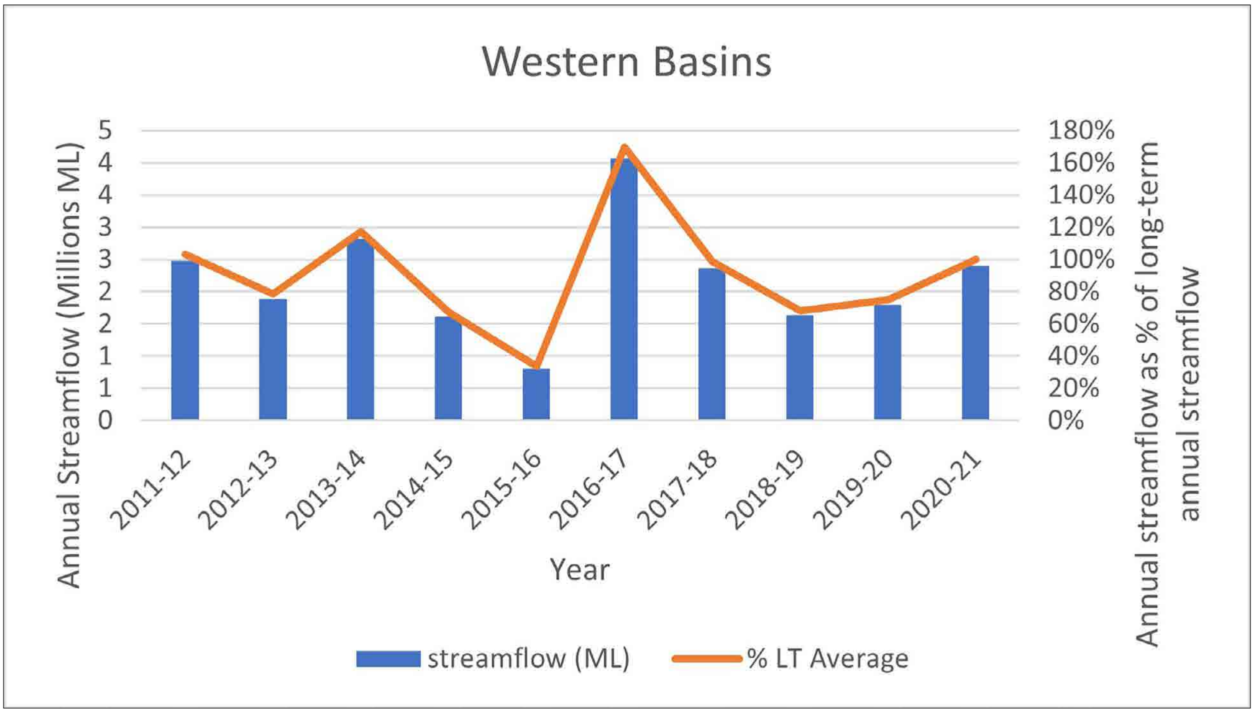


Figure WR37: Annual stream flow in ML and as a percentage of the long-term average stream flow in the Western Basins from 2011-12 to 2020-21.[1778]

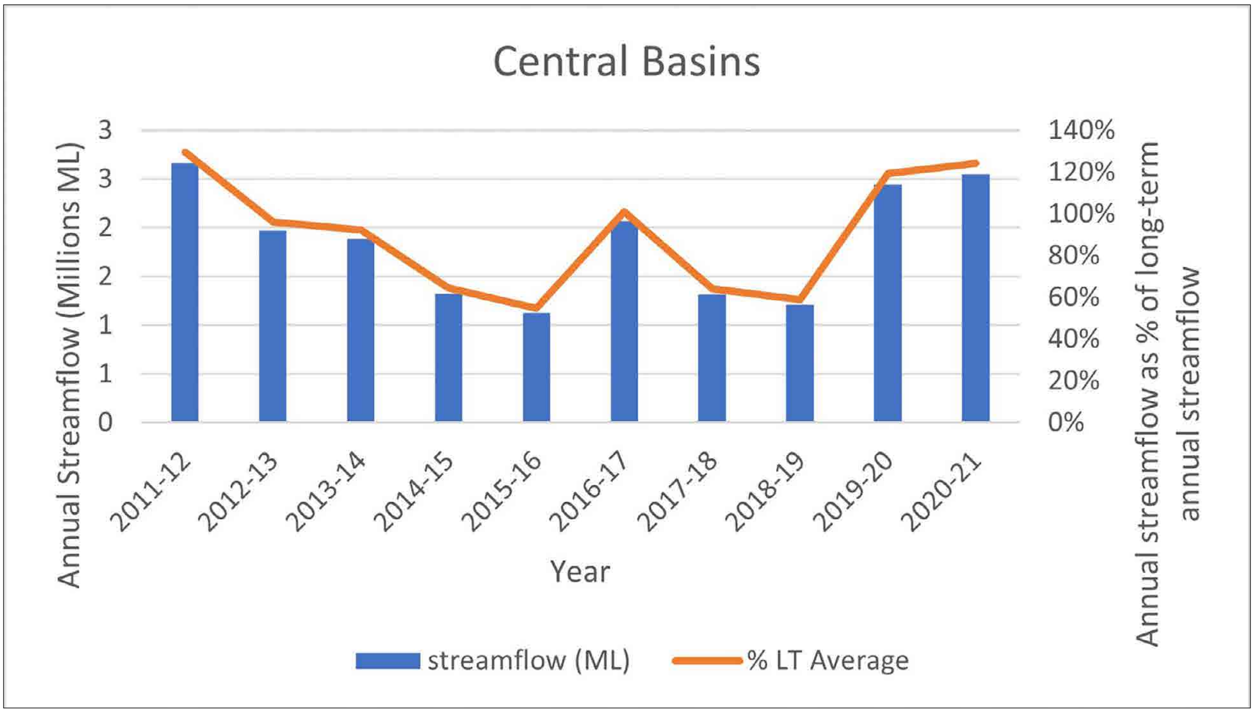


Figure WR38: Annual stream flow in ML and as a percentage of the long-term average stream flow in the Central Basins from 2011-12 to 2020-21.[1779]

[1778] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

[1779] Ibid.

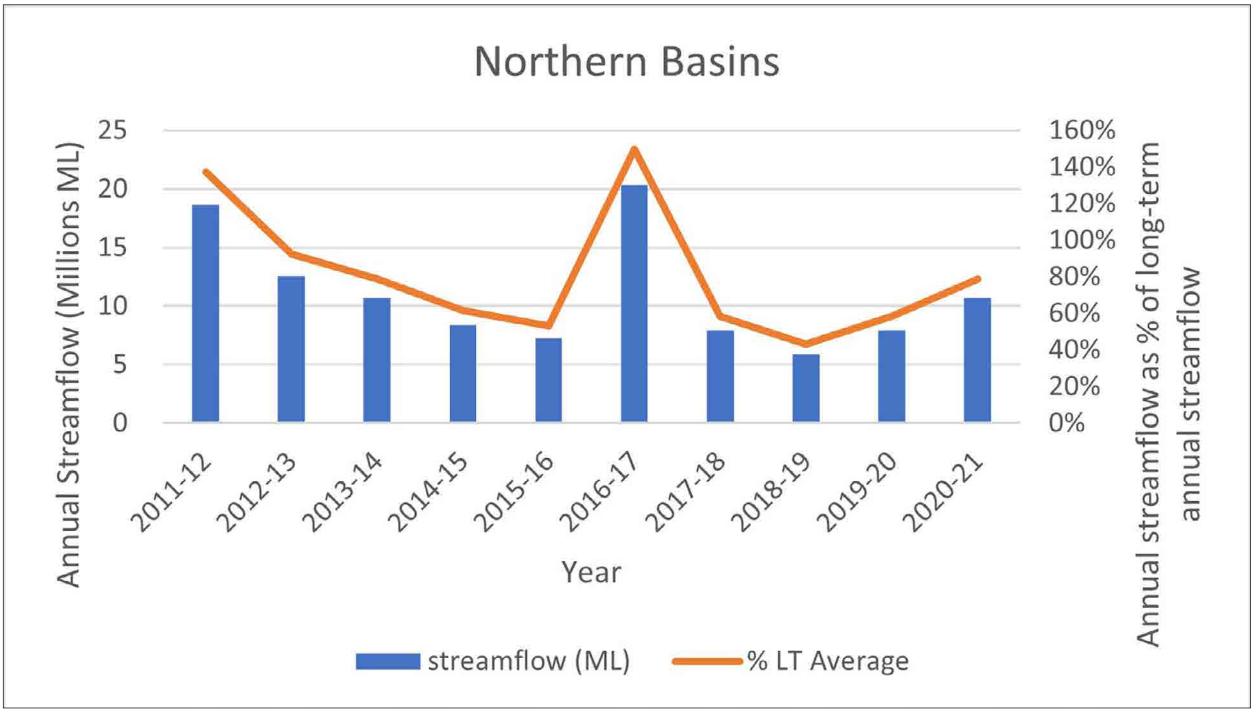


Figure WR39: Annual stream flow in ML and as a percentage of the long-term average stream flow in the Northern Basins from 2011-12 to 2020-21.[1780]

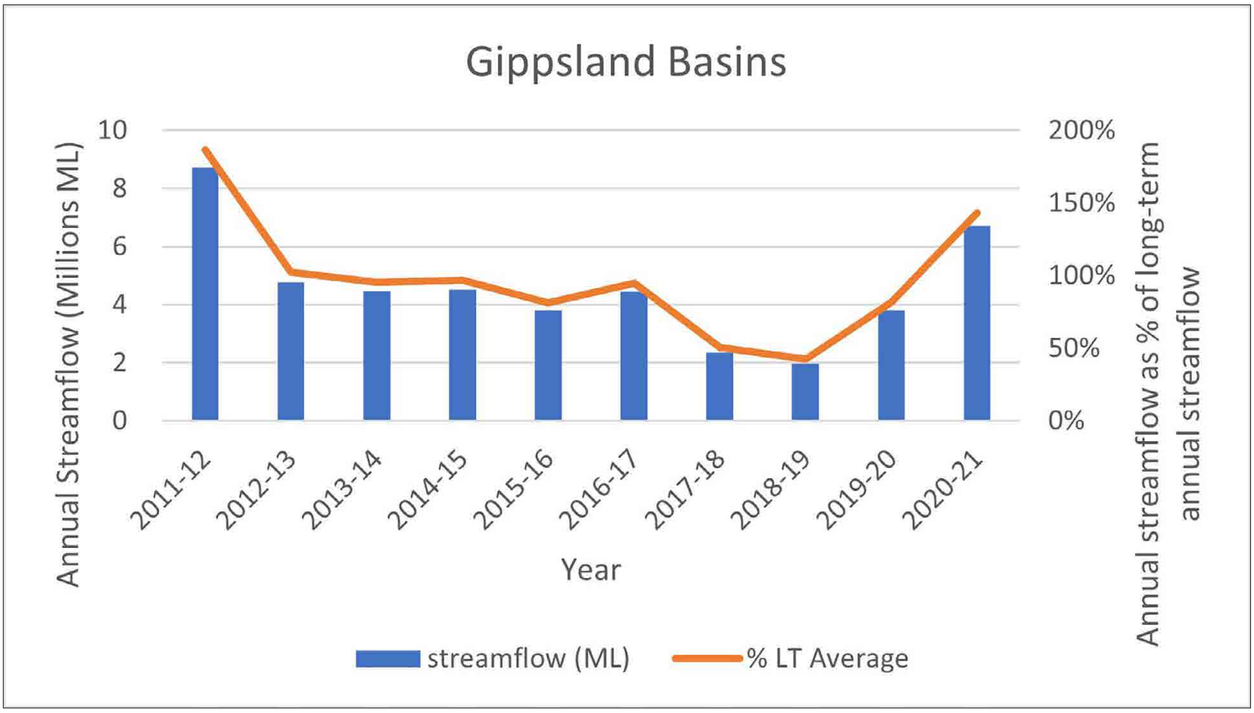


Figure WR40: Annual stream flow in ML and as a percentage of the long-term average stream flow in the Gippsland Basins from 2011-12 to 2020-21.[1781]

[1780] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

[1781] Ibid.

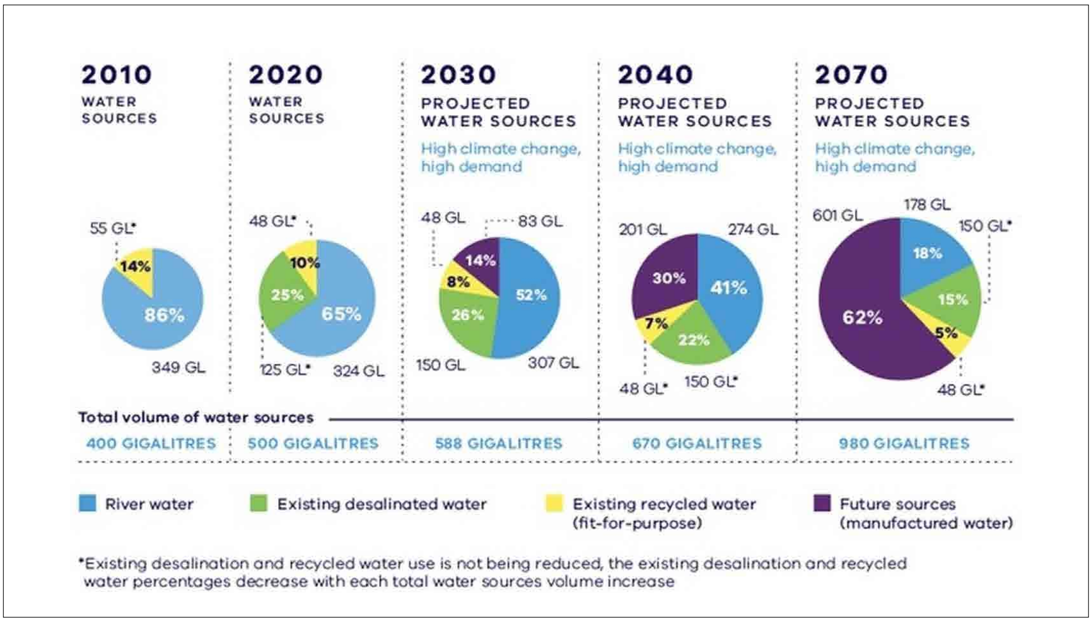
Inland waters — Water resources

The long-term decline in storage levels and the growth of Victoria's population, which is expected to increase from the current 6.7 million to 11 million by 2056, will increase pressure on the state's water resources.[1782] Average annual runoff is likely to decline over the coming decades, with the greatest reductions expected in the southwest of the state. Increased bushfire intensity and frequency, also projected under climate change scenarios, could lead to water quality issues in waterways and water storages. The East Gippsland and North East CMAs observed this in their regions after the 2019-20 bushfires.[1783, 1784]

Alleviating the pressure on water security in rural and urban communities, while also maintaining the values of wetlands and waterways, will likely require improvements in the efficiency of water use, especially in irrigated agriculture, the increased use of recycled water (see Indicator WR:05) and desalinated water, and water restrictions.[1785] Groundwater resources are also being used, however, assessment of Indicator WR:07 reveals that groundwater is a limited resource that could also decline.

The Central and Gippsland Region Sustainable Water Strategy projected that: 'by 2050, manufactured water sources could supply up to 65% of Melbourne's water needs, up from 35% in 2020. This could increase to 80% by 2070.'[1786] Manufactured water is desalinated sea water and fit-for-purpose recycled water and treated stormwater. Orders for water from the Wonthaggi desalination plant have been increasing, as shown by Table WR7, and are expected to become a feature of the state's annual water supply, rather than as a stop-gap measure. By 2040, it is expected that at least 22% of Melbourne's annual water demand will be serviced by the plant (Figure WR41). The strategy also projects that:

- the use of river water will decline from its 2020 level of 324 GL per year to 178 GL per year by 2070
- manufactured water will increase from 83 GL per year in 2030 to 601 GL per year in 2070
- desalinated water will increase from the 2020 figure of 48 GL to 150 GL in 2070.



*Existing desalination and recycled water use is not being reduced, the existing desalination and recycled water percentages decrease with each total water sources volume increase

Figure WR41: Greater Melbourne's expected transition to using more manufactured water between 2010 and 2070.[1787]

[1782] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victoria in future 2019: Population projections 2016 to 2056', Melbourne, Victoria.

[1783] East Gippsland catchment management authority (CMA) 2021, 'East Gippsland CMA annual report 2020-21', Bairnsdale, Victoria.

[1784] North East catchment management authority (CMA) 2021, 'North East CMA annual report 2020-21', Wodonga, Victoria.

[1785] There are five permanent water saving rules across the state that restrict the use of water for car washing, the watering of residential and public gardens, the cleaning of hard surfaces and the filling of water features such as fountains. No Victorian towns had any other water restrictions in 2020-21.

[1786] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Central and Gippsland region sustainable water strategy', Melbourne, Victoria.

[1787] Ibid.

Inland waters — Water resources

Table WR7: Volume of water ordered from the desalination plant 2016-17 to 2022-23 and its percentage of Melbourne's water storage capacity and Melbourne's water consumption.[1788]

Year	Volume ordered (GL)	Percent (%) of storage capacity in Melbourne storages (1,812GL in May 2022)[1]	Percent (%) of annual consumption in Melbourne (440GL in 2020-21)[2]
2016-17	50	2.8	11.4
2017-18	15	0.8	3.4
2018-19	15	0.8	3.4
2019-20	125	6.9	28.4
2020-21	125	6.9	28.4
2021-22	125	6.9	28.4
2022-23	15 [3]	0.8	3.4

[1] *See Table WR6.*

[2] *Melbourne Water 2021, 'Melbourne's water outlook 2022', Melbourne, Victoria.*

[3] *The delivery of the 2022-23 desalination order was ceased in September 2022. Only 4 GL had been delivered at the time the plant ceased production. On advice from Melbourne Water, the State requested that AquaSure cease delivery of the 15GL. Around 4GL of the order had been delivered at the time the plant ceased production.*

Bonnie Doon 2023.

Credit: Neisha Breen. © Neisha Breen.

1788. Department of Environment Land, Water and Planning (DELWP), 'Desalination' https://www.water.vic.gov.au/water-grid-and-markets/desalination Accessed 29 August 2022.

Inland waters — Water resources

Indicator WR:02 Interception of surface water by small farm dams

WR:02 Interception of surface water by small farm dams

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡 (southern rivers) ● (northern rivers)	↙	🟡	🟡	?	🟡
Data source(s):	DELWP					
Measure(s):	Likelihood of dams contributing to a long-term decline in available surface water					

Why this indicator?

Small farms dams are an important water resource for farming operations and can also provide habitat for aquatic life. However, they intercept water that would normally flow into waterways, placing pressure on a river basin's water balance and ultimately influencing the allocation of surface water to consumptive uses and the environment.

NB: This is a modified SoE 2023 indicator that provides greater focus on the impacts of small dams and was formed by modifying the measure of the SoE 2018 indicator 'WR:05 Number of dams, weirs and levees'.

Criteria used for status assessment

Good: Interception by small farms dams has a low likelihood of contributing to a long-term decline in available surface water

Fair: Interception by small farms dams has a moderate likelihood of contributing to a long-term decline in available surface water

Poor: Interception by small farms dams has a high likelihood of contributing to a long-term decline in available surface water

Why this assessment in 2023?

There are insufficient data to determine a statewide status, hence the focus on southern rivers (future release of the LTWRA for northern basins will fill that gap). Based on the above criteria, the likelihood of small farm dams impacting surface water availability ranges from good to poor, with the overall result rated as fair. Spatial data on the dams are well documented in the Victorian water accounts. The growth rate in the number of dams has slowed; however, the trend in terms of impact continues to deteriorate.

Summary of State of the Environment 2018 Report assessment

- Victoria has about 450,000 dams that range in size from major storages to small farm dams, which are the most common.
- Modification of natural flow regimes may affect biodiversity, alter riverine habitats, and facilitate the invasion of exotic species.
- Changes to the variability and volume of flow, combined with altered land-use practices, have caused nutrient contamination and contributed to poor water quality.

Critical data used for the 2023 assessment

- Data on small farm dams based on new methodologies, modelling and the use of satellite technology
- Academic and citizen-science research
- Annual Victorian Water Accounts Reports

2023 assessment

Indicator WR:01 reviewed the storage levels for 28 major storages in Melbourne and regional areas. However, most of Victoria's more than 450,000 dams are small and used on farms for irrigation (generally >5ML in capacity) and stock and domestic water supply (generally <5ML in capacity).

Inland waters — Water resources

In comparison with the capacity of the state's major storages, which in May 2022 was 13,869,907 ML, the capacity of small farms dams in 2020-21 was only 693,126 ML.[1789] However, they do have implications for river basin water balances.

Small farm dams play an important role in rural communities by providing water for stock, irrigation, domestic use, and recreation. They also provide habitat and refuges for native frogs, waterbirds, fish, invertebrates and reptiles. Threatened species can also be supported by small farm dams and have the potential to bridge gaps between fragmented habitats.

The Fish in Supplementary Habitats (FISH) program is a partnership between the Arthur Rylah Institute, the MDBA, Goulburn Broken CMA, local community groups and landowners. It is working to establish refuge populations of the threatened southern pygmy perch in small farm dams.[1790] To date, 486 perch have been translocated from Castle Creek, Hughes Creek and Seven Creeks, and one private property to four farm dams.

In recent decades, many of the small dams have been constructed in peri-urban areas surrounding Melbourne and regional population centres, such as Ballarat, Bendigo, Shepparton and South Gippsland, as larger farms have been subdivided into smaller allotments and as landholders sought to increase their water security at the time of the Millennium Drought (Figure WR42). Their impact on the flow of creeks, streams and rivers is now more widely recognised.

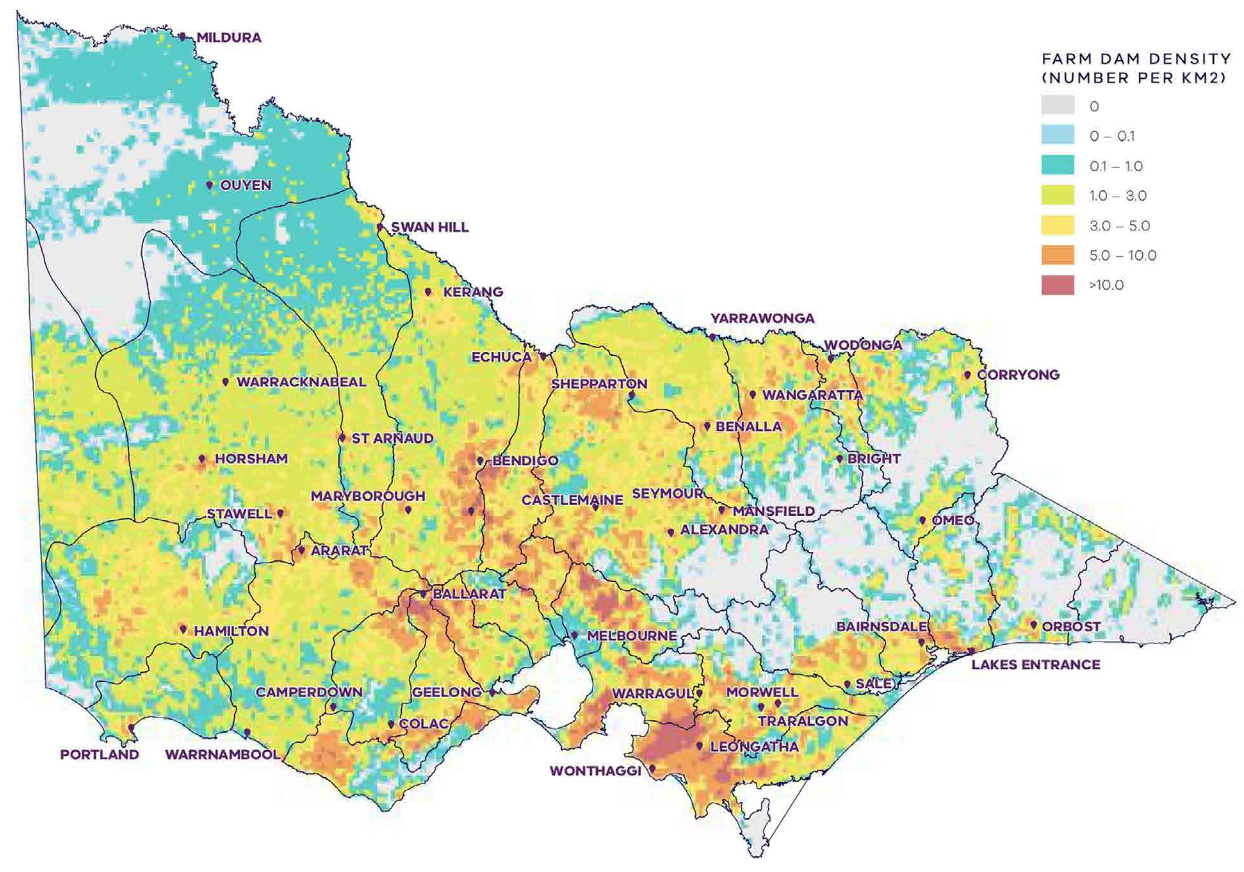


Figure WR42: Density of farm dams in Victoria, including both small catchment dams and licensed commercial and irrigation dams, as reported in 2021.[1791]

1789. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.
1790. Raymond S 2020, 'Landholders providing new homes for southern pygmy perch in Victoria', Finterest, 22 January 2020.
1791. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Central and Gippsland region sustainable water strategy discussion draft', Melbourne, Victoria.

In 2018-19, small farm dams in the Maribyrnong River catchment intercepted 11% of catchment inflows.[1792] In the Moorabool River catchment, the figure can increase from 17% to 32% in a dry year, the time of greatest impact.[1793] People for a Living Moorabool have estimated growth of 0.9% annually in the number of small farm dams in the river's catchment, largely due to dams being excavated to provide foundations for new wind turbines and from the clearing of plantations (the dam increases the potential sale value of the farm).[1794]

Small farm dams are often upstream in catchments and can reduce environmental flows and impact water security for downstream users. However, there is no metering of stock and domestic dams, which means that estimating their impact is difficult. It is also challenging to assess the impact of farm dams alone. When combined with the impact of climate change and land-use change, their impact becomes more significant.

An analysis of small stock and domestic farm dams found that dam volume was a good predictor of its impact, negating the need for spatial analysis.[1795] Neal et al. (2002) found that, for every megalitre of farm dam capacity developed, there was a 1.0 to 1.3 ML reduction in stream flow per year.[1796] A review of farm dams in the Wimmera between 1994 and 2004 found that 60% of wetlands had been modified, mainly for farm dam construction.[1797]

In Victoria, the highest growth rate for small farm dams was during the Millennium Drought (1998-2010) as existing peri-urban landholders and those who had bought allotments in rural lifestyle subdivisions sought to secure water supplies.[1798] Figure WR43 charts the growth of stock and domestic dams from 2000 to 2015, with a projection for 2020. The decline in growth rate after the drought was partly in response to the *Farm Dams Act 2003*, which included licensing of irrigation dams and a cap-and-trade system in capped catchments.[1799]

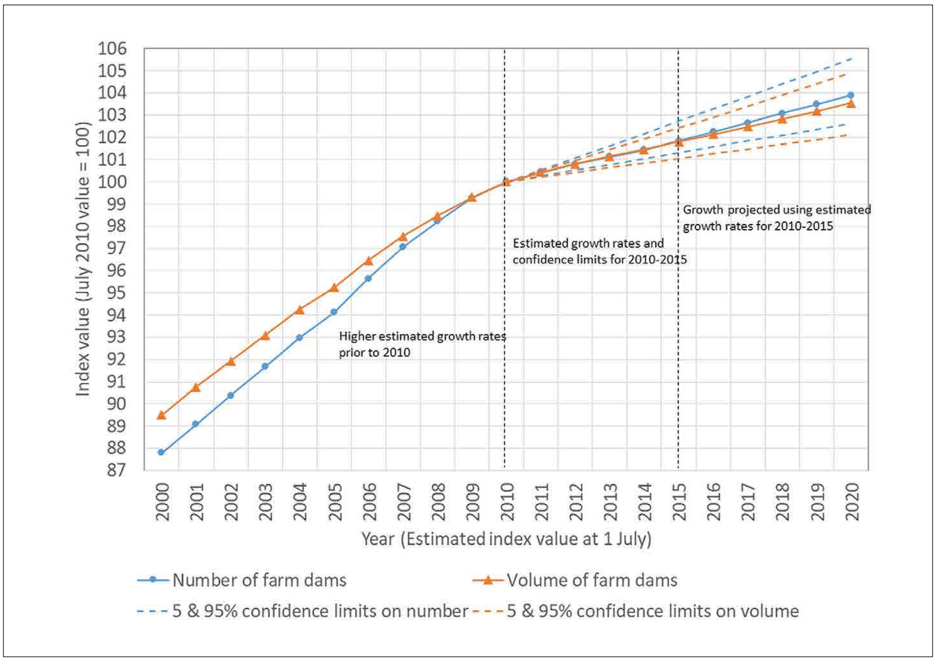


Figure WR43: Cumulative number and volume of stock and domestic farm dams across Victoria for the period 2000 to 2015 (relative to an index value of 100 at July 2010), with a projection to 2020.[1800]

1792. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Central and Gippsland region sustainable water strategy discussion draft', Melbourne, Victoria.
1793. Ibid.
1794. Cameron Steele, People for a Living Moorabool, pers. comm.
1795. Hydrology and Risk Consulting 2021, 'Modelling the impact of D&S farm dams on water availability in Victoria', Blackburn, Victoria.
1796. Neal B, Nathan R, Schreider S, Jakeman A 2002, 'Identifying the separate impact of farms dams and land use changes on catchment yield', *Australasian Journal of Water Resources*, 5(2).
1797. Nathan R and Lowe L 2012, 'The hydrologic impacts of farm dams', *Australasian Journal of Water Resources*, 16(1), pp. 75-83.
1798. Department of Environment Land, Water and Planning (DELWP), 2021, 'Central and Gippsland region sustainable water strategy discussion draft', Melbourne, Victoria.
1799. Morris C, Stewardson M, Finlayson B, Godden L 2019, 'Managing cumulative effects of farm dams in Southeastern Australia', *Journal of Water Resources Planning and Management*, 145, pp. 05019003.

The LTWRA of the state's southern river basins also mapped the density of small farms dams (Figure WR44), along with the relative contribution of their increased interception to the total long-term decline in available surface water (Figure WR45). There is a correlation between farm dam density in Figure WR44 and the level of interception in Figure WR45. The farm dams in the Barwon, Yarra and Bunyip River basins have a high likelihood of contribution towards declines in surface water. On the other hand, as there are fewer farm dams in the far west and far east of the state, there is a relatively smaller impact on water resources.

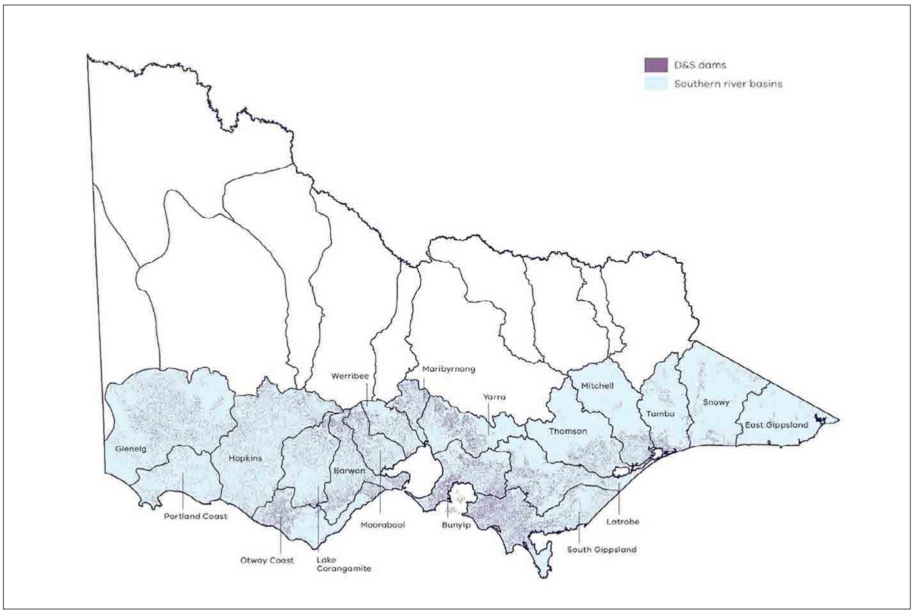


Figure WR44: Location of small farm dams for domestic and stock water supply in the southern river basins of Victoria, as reported in 2020.[1801]

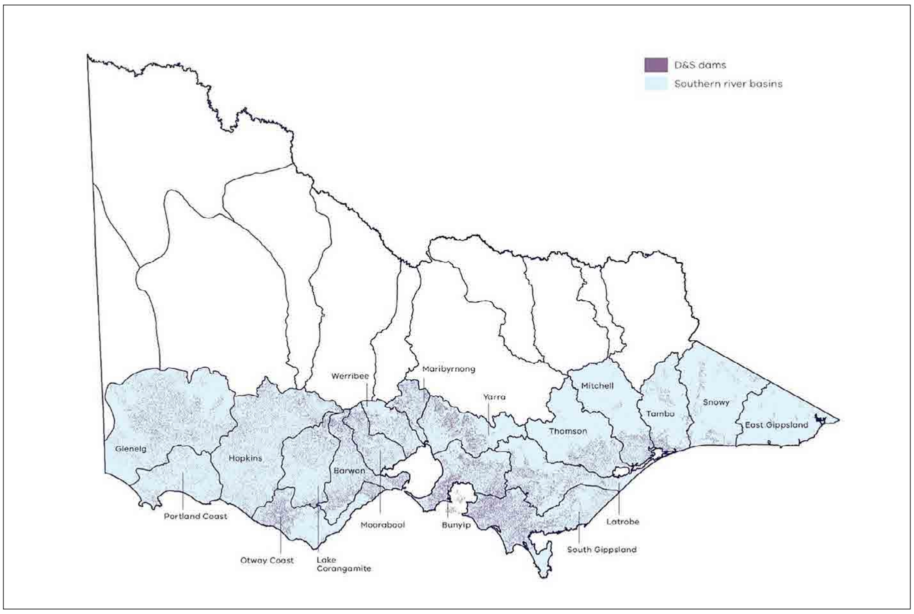


Figure WR45: Relative contribution of the increase in interception by domestic and stock water supply dams to the total long-term decline in available surface water within the southern river basins of Victoria, as reported in 2020.[1802]

1800. Hydrology and Risk Consulting 2021, 'Modelling the impact of D&S farm dams on water availability in Victoria', project report final, Blackburn, Victoria.
1801. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Long term water resource Assessment for southern Victoria, overview report', Melbourne, Victoria.
1802. Ibid.

Although the focus of this indicator's assessment is the impact of farm dams on regional water balances, recent research has investigated their generation of greenhouse gas emissions. Ollivier et al. (2018) analysed data to estimate the greenhouse gases emitted from small farm dams in Victoria.[1803] The authors estimated that the CO2-e/day emission rate of farm dams is 4,853 tonnes, which is 3.1 times higher than statewide reservoir emissions despite farms dams covering only 0.94 times the comparative area. It was also found that carbon dioxide and methane emissions were significantly higher in farm dams used for livestock-rearing rather than cropping. The study recommended that greenhouse gas emissions from farm dams should be included in global carbon budgets to fill a gap in climate change mitigation policy. Malerba et al. (2022) found that methane emissions from farm dams can be halved if stock are excluded by fencing, which could also improve water quality and reduce nutrient enrichment.[1804] The exclusion of stock can also increase vegetation cover and enrich macroinvertebrate biodiversity.[1805]

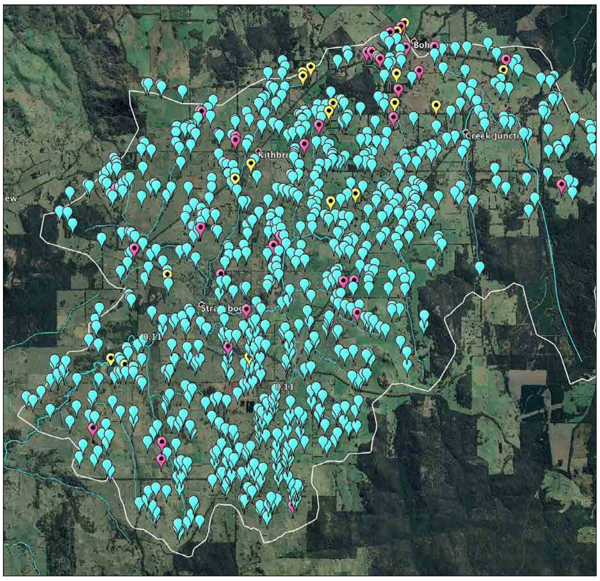


Figure WR46: Small farm dams in the Seven Creeks catchment above Polly McQuinn's Weir in 2020.[1808] Small dams are presented in blue, medium dams in yellow and large dams in pink.

Impact of small farm dams in the Strathbogie Ranges

The impact of small farm dams on stream flows and water balances varies across the state, river basins and sub-catchments. In an analysis of farm dams in the Strathbogie Tableland, Lobert (2020) found 864 dams in the 15,300 ha of the Seven Creeks catchment above Polly McQuinn's (Figure WR46).[1806] Of the 864 dams, 811 were small (<2 ML), 21 medium (2–5 ML) and 32 large (>5 ML) and their combined storage capacity was estimated at 1,006 ML.

Lobert (2020) concluded that:

> 'the impact on stream-flow during the drier months is likely to be high because these dams can intercept runoff that would otherwise provide freshing flows in summer (when base-flow is at its lowest)' ... and ... 'demand for reliable, good quality water is high and will only increase as rainfall patterns change and the catchment becomes drier' ... and... 'the sheer number of farm dams on the Strathbogie Tableland, along with the amount of water they divert away from surface flow, suggests they may already be having a significant impact.' [1807]

[1803] Ollivier Q, Maher, D, Pitfield C. Macreadie P 2018, 'Punching above their weight: Large release of greenhouse gases from small agricultural dams', *Global Change Biology*, 25, pp. 721-732.

[1804] Malerba M, Lindenmayer D, Scheele B, Waryszak P, Yilmaz I, Schuster L, Macreadie P 2022, 'Fencing farm dams to exclude livestock halves methane emissions and improves water quality', *Global Change Biology*, 28, pp. 4701–4712.

[1805] Westgate M, Crane C, Smith D, O'Malley C, Siegrist A, Florance D, Lang E, Crane M, Hingee K, C. Scheele B, Lindenmayer D 2021, 'Improved management of farm dams increases vegetation cover, water quality, and macroinvertebrate biodiversity', *Ecology and Evolution*, 12, pp. e8636.

[1806] Lobert B 2020, 'Farm dams on the Strathbogie Tableland', Bogies and Beyond Groundwater Monitoring Project, Strathbogie Ranges – Nature View, 20, https://strathbogierangesnatureview.wordpress.com/2020/08/20/farm-dams-on-the-strathbogie-tableland/ Accessed 20 March 2023.

[1807] Ibid.

[1808] Ibid.

Inland waters — Water resources

Indicator WR:03 Surface water harvested for consumptive use

WR:03 Surface water harvested for consumptive use						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🟡	↙	🟢	🔴	→	🟢
Data source(s):	DELWP					
Measure(s):	Total surface water diversions Water leaving basins					

Why this indicator?

Water consumption reduces the water available to support aquatic ecosystems and increases the impact of dry conditions on biodiversity. Climate change will reduce the inflows and outflows of river basins.

NB: This indicator was ‘WR:06 Surface water harvested for consumptive use’ in the SoE 2018 Report.

Criteria used for status assessment

Good: On average, over a 5-year period, ≥21 of Victoria’s 28 river basins had ≥75% of water leaving the basin

Fair: On average, over a 5-year period, 14 to 20 of Victoria’s 28 river basins had ≥75% of water leaving the basin

Poor: On average, over a 5-year period, <14 of Victoria’s 28 river basins had ≥75% of water leaving the basin

Why this assessment in 2023?

Water flows and consumption are very well monitored across the state. Sixteen of the 28 basins have ≥75% of stream flows leaving the basin. This indicates a status of fair — an improvement on the poor assessment in SoE 2018. This difference is due to the use of assessment criteria for this indicator, and to wetter years since the SoE 2018 Report. Climate change projections indicate that the trend will deteriorate. However, the data are variable and fluctuate due to weather patterns.

** The Mallee basin does not have recorded stream flows, so only 28 of the state’s 29 basins are used in the assessment criteria. In the Millicent basin, all stream flows are diverted, with none leaving the basin.*

Summary of State of the Environment 2018 Report assessment

- During periods of reduced rainfall, most of the available water was extracted to supply domestic, industrial and agricultural needs. In some cases, it was likely that too much water was being taken out of many of Victoria’s rivers, wetlands and aquifers.
- The East Gippsland and Snowy basins generally recorded the highest proportion of total flows leaving their basins, while the Avoca, Wimmera, Loddon, Moorabool and Werribee basins recorded the lowest proportions.

Critical data used for the 2023 assessment

- Annual Victorian Water Accounts Reports
- Central and Gippsland Region Sustainable Water Strategy 2022

2023 assessment

An analysis of flows leaving a river basin gives some insight into the pressure that water diversions for consumptive uses can place on aquatic systems. However, variations in the interaction of ecosystem processes and seasonal flows between river basins make difficult any statewide assessments of the impact that such diversions have on river health.[1809]

[1809] Department of Environment, Land, Water and Planning (DELWP) 2022, ‘Victorian water accounts 2020-21’, Melbourne, Victoria.

Inland waters — Water resources

The percentage of basin flows that leave each of the Victoria's river basins varies across the state. The lower the percentage that leaves the basin, in general, the higher the diversion of water and the subsequent pressure on aquatic systems. If inflows are falling, but diversions remain the same or increase, then outflows will also decline. Those basins with little or no regulation have 90% to 100% of their flows leaving the basin, whereas those basins with regulated diversions in north and near Melbourne and Geelong have much lower percentages leaving the basin. For the 5-year period from 2016-17 to 2020-21, 17 of the river basins in the state had greater than 75% of their flows leaving the basin and 10 had less than 75% of flows.[1810]

Figure WR47 provides a statewide snapshot of flows leaving Victoria's river basins from 2003-04 to 2020-21. The wetter years of 2019-20 and 2020-21 resulted in an increase in volumes and percentages of total flows leaving river basins. However, the proportion of water leaving was generally stable.

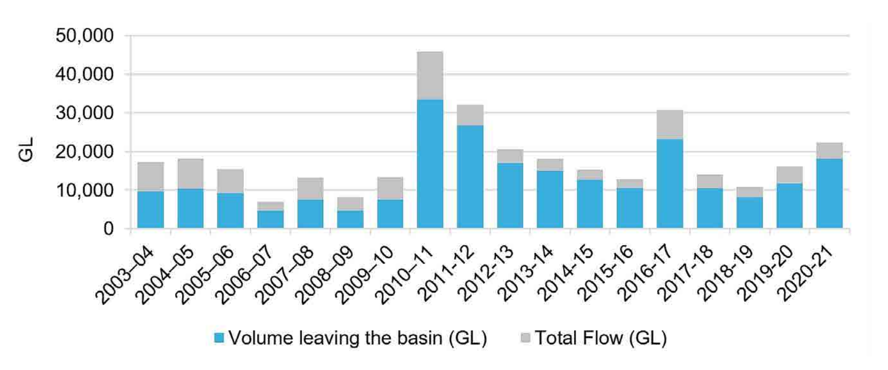


Figure WR47: Volume leaving Victorian river basins, as a proportion of total flows from 2003-04 to 2020-21.[1811]

This is also generally indicated in Figure WR48 which charts the changes in the percentage of stream flows leaving the basins from 2011-12 to 2020-21 against the percentage of river basins. There is considerable variation across the years, although the last three years graphed are relatively stable.

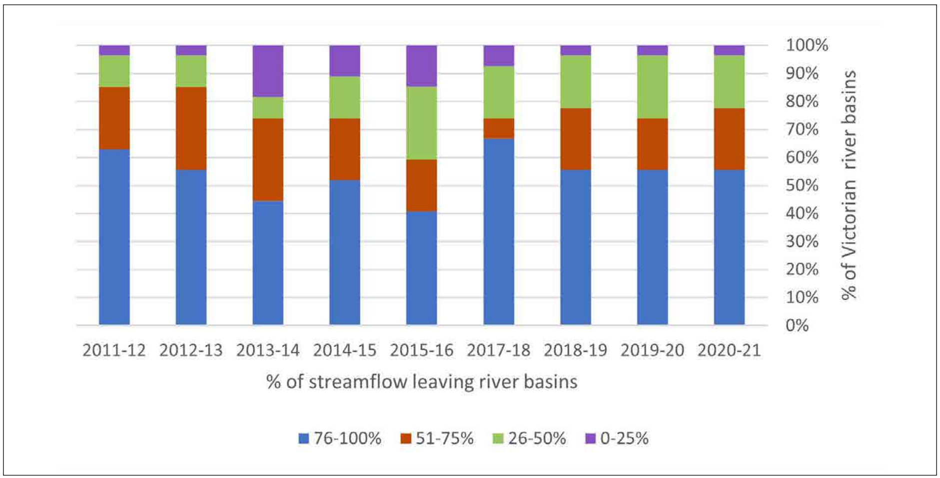


Figure WR48: Percentage of stream flows leaving Victorian river basins from 2011-12 to 2020-21.[1812]

[1810] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

[1811] Ibid.

[1812] Ibid.

Inland waters — Water resources

The volumes and percentages of river flows available for sharing between consumption or the environment vary across the state's river basins. However, the LTWRA for southern Victorian basins reported decreases in the environment's share of available surface water in the Yarra, Moorabool and Werribee basins (and Thomson and Barwon), and the three basins had also experienced the highest reductions in long-term water availability.[1813]

Table WR8 provides data on the main consumptive uses of surface water between 2016-17 and 2020-21. There is some variability in the volume (ML) and percentage of surface water used for the four main uses — irrigation, urban and commercial, livestock and domestic and power generation. Irrigation is the dominant user, ranging from 71% to 78% of the total water taken over the five years, with urban and commercial the second major user. Water consumption by the agricultural sector varies with annual rainfall patterns, while urban use is relatively stable and consumption by power generation increasing over the period.

Surface water diversions for consumption have a direct influence on the health of waterways. In the LTWRA, waterway health is described as including:

- presence, abundance and diversity of species
- extent and connectivity of habitats
- breeding and feeding opportunities for fish, frogs, birds and other animals
- carbon and nutrient cycling
- sediment transport processes
- water quality.

The Index of Stream Condition (ISC) provides other data that can be used to assess water flows and waterway health, although the next report is not due until 2028. Under the ISC, the sub-index 'hydrology', refers to 'the amount of water that is within the river channel at a particular point in time at a particular location. A minimum of 15 years of monthly flow data are used' and covers:

- low flows: the two lowest monthly flows in a year
- high flows: the two highest monthly flows in a year
- zero flows: the period of time that there is no flow
- seasonality: a measure of the shift in the timing of the maximum flow month and the minimum flow month
- variability: the difference in magnitude between the high and low flows within each year.

The ISC scored the hydrology of Victoria's 29 river basins from 0 to 10, with lower scores indicating poor hydrological values.[1814] Of the 1,132 river reaches surveyed, 54% were scored 5 or below, 32% scoring 6, 7 or 8, and 14% scoring 9 or 10. Higher scores were generally found in the east whereas lower scores found along the northern rivers, in the south-west and around Melbourne.

[1813] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Long term water resource Assessment for southern Victoria, overview report', Melbourne, Victoria.

[1814] Department of Environment and Primary Industries (DEPI) 2010, 'Index of stream condition: The third benchmark of Victorian river condition', Melbourne, Victoria.

Inland waters — Water resources

Table WR8: Main uses of surface water from 2016-17 to 2020-21.[1815, 1816, 1817, 1818, 1819]

Use	2016-17	2017-18	2018-19	2019-20	2020-21
Irrigation (ML)	2,267,925	2,781,684	2,599,879	1,910,166	2,114,852
Percent of total consumption (%)	71	78	77	71	75
Urban and commercial (ML)	663,545	630,414	655,647	651,765	535,129
Percent of total consumption (%)	21	18	19	24	19
Domestic and livestock (ML)*	245,238	89,861	72,208	100,375	105,630
Percent of total consumption (%)	8	3	2	4	4
Power generation (ML)	21,274	48,446	49,753	41,409	50,761
Percent of total consumption (%)	1	1	2	1	2
Total (ML)	3,197,982	3,550,404	3,377,486	2,703,715	2,806,372

**Domestic and stock is not metered.*

Warby-Ovens National Park - Lower Ovens Reflections 2011.
© Parks Victoria.

[1815] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2016-17', Melbourne, Victoria.
[1816] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2017-18', Melbourne, Victoria.
[1817] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2018-19', Melbourne, Victoria.
[1818] Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian water accounts 2019-20', Melbourne, Victoria.
[1819] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.

Inland waters — Water resources

Indicator WR:04 Percentage of compliance with entitlements for the take of surface water

WR:04 Percentage of compliance with entitlements for the take of surface water

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	→	●	●	→	●
Data source(s):	DELWP					
Measure(s):	Percentage of compliance with extraction entitlements for surface water					

Why this indicator?

The use of extraction entitlements supports the best-practice management of water resources and reduces impacts on aquatic ecosystems.
NB: This is a modified SoE 2023 indicator formed by modifying the measure for the SoE 2018 indicator 'WR:07 Percentage of waterways and groundwater areas subject to extraction, with a limit on extraction' in the SoE 2018 Report.

Why this assessment in 2023?

Although the volume of water taken in each of Victoria's river basins over the past four years is below the bulk entitlements, and there is compliance with the take and use licences for unregulated surface water, the entitlements have not been set based on an ecologically sustainable level of take.

Rising numbers of potential breaches of the Victorian *Water Act 1989* by individual consumers of non-urban water are largely due to improved monitoring and enforcement actions, not increasing volumes of water theft. With up to 3.6% of non-urban water stolen, the Victorian Government has set a target of 1%. It is anticipated that progress towards this target will be assessed in the SoE 2028 Report.

Summary of State of the Environment 2018 Report assessment

- Irrigation continues to be the largest consumptive use of surface water in the state, comprising 78% of all water taken from 2011-12 to 2015-16.
- The volume of water taken for consumptive use under Victorian surface-water entitlements between 2011-12 and 2015-16 peaked during 2012-13 at approximately 4,300 GL and was the lowest in 2011-12 at approximately 3,700 GL.
- The primary driver for the decline since 2012-13 was a reduction in the use of surface water for irrigation.
- Sustainable diversion limits will operate from 2019 in the southern basin of the Murray-Darling Basin.

Critical data used for the 2023 assessment

- Annual Victorian Water Accounts Reports

2023 assessment

The Victorian water entitlement framework sets out the ways in which individuals, companies, government and water corporations can share water. In Victoria, all surface water systems and groundwater systems are capped. Any extraction within these limits is legally permissible and deemed to be a sustainable level of take.

The permissible level of take within the entitlement volume is informed by resource availability and seasonal conditions and is aimed at avoiding impacts on the environment and the resource. For example, in unregulated surface-water systems and groundwater systems, rosters and restrictions are used to reduce the level of take for a certain period (e.g. over summer months) when there are low flows or low aquifer levels. Where restrictions are in place for rivers in dry conditions, total take (compared to entitlement volume) may be low, but this is not an indicator of environmental health or benefit.

In declared surface-water systems, storage managers allocate water to entitlements each year according to the available water in their storages. When allocations are low, water consumers receive a small percentage of their entitlement volume, as do environmental water holders.

Figure WR49 charts the change in the percentage of entitlement volumes diverted for consumptive use between 2003-04 and 2020-21. High levels of diversion tend to coincide with drier years, such as during the Millennium Drought of 1998 to 2010 when, in 2003-04, the percentage of the surface-water entitlement taken for surface water was more than 90%. Demand for surface water, especially by irrigators, is higher during such dry times. Conversely, the lower percentage diversions occur during wetter years, such as 2010 and 2011 and 2020 and 2021 when, for example, demand for water to irrigate crops and pastures was lower.

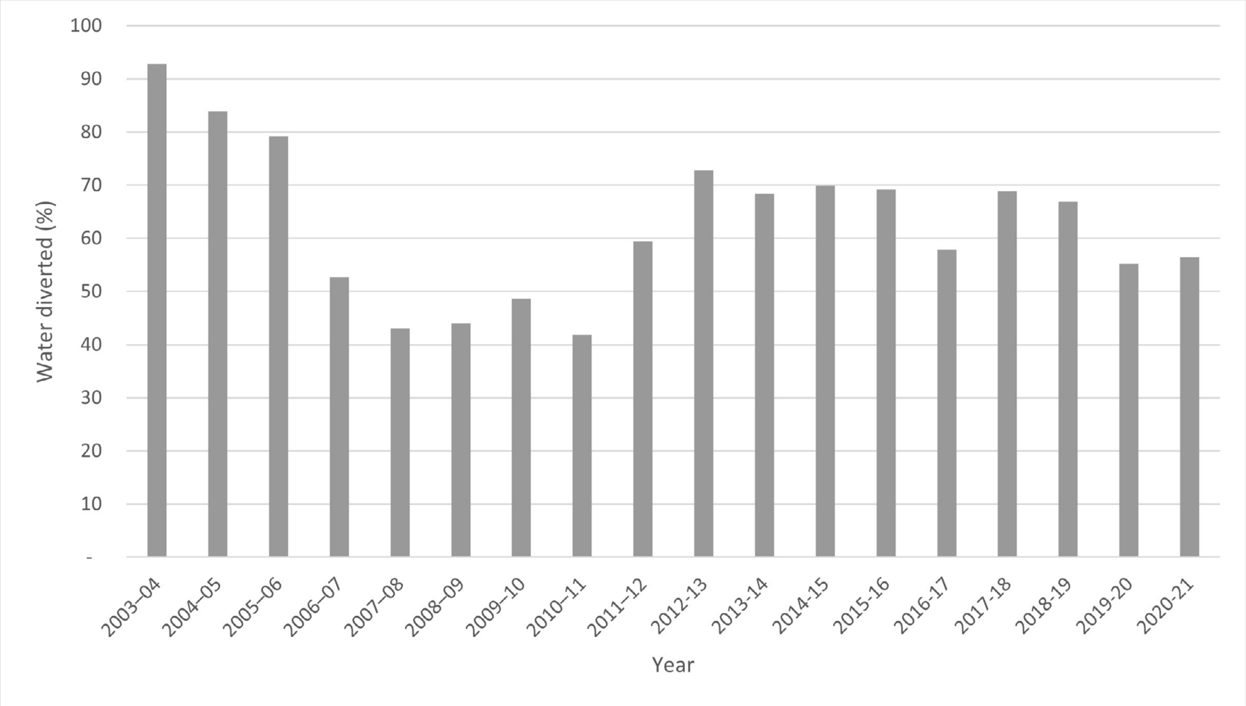


Figure WR49: Percentage of surface water entitlement volume diverted for consumptive use from 2003-04 to 2020-21.[1820]

Table WR9 provides data on the availability of surface water, the entitlements for its use and the volumes taken, the percentages of total water and entitlements taken, and the volume of unused entitlements. The percentage of the entitlements taken ranged between 52.2% and 66.1%. Total water taken was highest in 2017-18, while the 2020-21 total volume taken was more than 740,000 ML less, coinciding with reduced take for irrigation and domestic and livestock uses. However, seasonal conditions and user behaviour are the primary drivers (and informed by allocations and/or rosters and restrictions) in determining the extent to which entitlement holders use their full entitlement volume each year. During wet years, there is a reduced need for irrigation and the watering of domestic gardens, sporting ovals and public parks. Changing farming practices (e.g. the replacement of livestock with dryland cropping) can also reduce water demand.

[1820] Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Inland waters — Water resources

Table WR9: Surface water and the use of entitlements from 2016-17 to 2020-21.[1821, 1822, 1823, 1824, 1825]

Volume and percentage	2016-17	2017-18	2018-19	2019-20	2020-21
Total surface water (ML)	30,907,414	13,968,960	10,681,744	16,662,382	22,304,578
Total entitlements (ML)	6,121,362	5,994,424	5,050,845	4,965,212	4,967,204
Total taken (ML)*	3,197,982	3,550,404	3,337,486	2,703,715	2,806,372
Percent of total taken/total surface water (%)	10.3	25.4	31.2	16.2	12.6
Percent of total taken/total entitlements (%)	52.2	59.2	66.1	54.5	56.5
Unused entitlements (ML)	2,923,380	2,444,020	1,713,359	2,261,497	2,160,832

* *Surface water diversions.*

A review of Victoria's water accounts for the years 2017-18 to 2020-21 showed that, with only a few exceptions, there was compliance with bulk entitlements and by holders of take and use licences for unregulated water across each of the state's river basins. However, the entitlements have not been set based on an environmentally sustainable level of take.

The Annual Water Compliance Report provides data on compliance breaches by individual consumers of non-urban water supplies. In 2014-15, there were 382 potential breaches of the Victorian Water Act, with 350 cases finalised, three prosecutions initiated, and one completed.[1826] By 2017-18, the number of alleged breaches had increased to 1,625, with 1,579 finalised, and there were 14 prosecutions initiated and 10 completed. The reasons for the increase, according to that year's water compliance report, were the:

> 'increased capacity of water corporations to detect breaches and resolve to take enforcement actions targeting overuse against an allocation bank account (unauthorised use), and strong demand for water in regulated surface water markets combined with dry conditions. In most cases, the amount of unauthorised use is small and dealt with through advisory or warning letters.' [1827]

For 2021-22, the annual compliance report cited 3,390 potential breaches, with 3,346 finalised.[1828] There were 10 prosecutions carried over for the previous year, 15 commenced and 10 finalised.

Prosecutions are the last step in the enforcement process. Other enforcement actions include a verbal warning, an advisory letter, a warning letter, statutory notices, lockdown, referral to other agencies and penalty infringement notices. The sending of a warning letter is the most common action followed by a notice. In 2021-22, enforcement actions in northern Victoria numbered 2,096, with 1,431 warning letters and 468 notices issued.[1829] By contrast, in southern Victoria where there are far fewer water users and licence holders, there were 46 enforcement actions that included 25 warning letters and seven notices.[1830]

1821. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2016-17', Melbourne, Victoria.
1822. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2017-18', Melbourne, Victoria.
1823. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2018-19', Melbourne, Victoria.
1824. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian water accounts 2019-20', Melbourne, Victoria.
1825. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.
1826. Department of Environment, Land, Water and Planning (DELWP) 2015, 'Compliance report 2014-15', https://www.water.vic.gov.au/water-for-agriculture/taking-and-using-water/compliance-reports/water-compliance-report-2014-15 Accessed 25 June 2023.
1827. Department of Environment, Land, Water and Planning (DELWP) 2018, 'Compliance report 2017-18', https://www.water.vic.gov.au/water-for-agriculture/taking-and-using-water/compliance-reports/compliance-report-2017-18, Accessed 25 June 2023.
1828. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Compliance report 2021-22', https://www.water.vic.gov.au/water-for-agriculture/taking-and-using-water/compliance-reports/water-compliance-report-2021-22, Accessed 25 June 2023.
1829. Ibid.
1830. Ibid.

Inland waters — Water resources

Although, unauthorised take is only one of several types of potential breaches — obstruction of water corporation officers and damage to metering equipment are other categories — it comprised 97% of all potential breaches in 2021-22.[1831]

Since 2014-15 there has been an increasing trend in the number of compliance breaches, however this does not necessarily indicate increasing water theft. The main cause of the increase identified by the 2021-22 compliance report were:

- increased investment by water corporations in metering (there were 52,000 meters in 2021-22, 30,841 of which have telemetry that provides real-time data on compliance), monitoring and data management, as well as gradual improvement in their compliance and enforcement policies and strategies
- the adoption by Victoria of a zero-tolerance approach to unauthorised take
- Victorian legislation in 2019 that increased the penalties for noncompliance.[1832]

A 2020 report on compliance and enforcement commissioned by the Victorian Government found that water theft was up to 3.6% of non-urban water volume. In response, the Government has set a target of 1% for water theft.[1833, 1834] It remains too early to determine the level of success in reaching the target under the zero-tolerance approach. It is anticipated that the SoE 2028 Report will have access to more data to guide its assessment of progress.

As mentioned above, there has been compliance with bulk entitlements and by holders of take and use licences for unregulated water across each of the state's river basins. However, the entitlements that have been set are not based on an environmentally sustainable level of take. The Commonwealth Water Act requires an environmentally sustainable level of take to be set and environmental priorities to be given primacy when establishing water allocations.

Maximising net economic returns from the use and management of water resources, also an object of the Commonwealth Water Act, is subject to two other objects:

- to ensure the return to environmentally sustainable levels of extraction for water resources that are overallocated or overused
- to protect, restore and provide for the ecological values and ecosystem services of the Murray-Darling Basin.
- In contrast, the Victorian Water Act has as one of its 14 purposes to ensure that water resources are conserved and properly managed for sustainable use for the benefit of Victorians now and into the future. The Central and Gippsland Region Sustainable Water Strategy's determination that 'water will not be taken away from farmers, and all existing water entitlements provided under the Victorian Water Act will be protected' has been made in that legislative context.[1835]

In the Central and Gippsland regions, it is projected that at least an additional 200 GL of water could be needed over the next 10 years for urban water supplies, irrigation, Traditional Owners and the environment. However, according to the Central and Gippsland Region Sustainable Water Strategy, that allocation would not cover the full needs of the region's major rivers:

> 'An estimated 380 gigalitres of water per year (on average) would be needed to meet the full environmental water requirements for major rivers in the Central and Gippsland Region – a volume greater than Melbourne's total annual residential water usage. This environmental water deficit cannot be met with a growing population and drying climate without taking water away from households, industry, businesses and farms – it is simply too large.' [1836]

[1831] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Compliance report 2021-22', https://www.water.vic.gov.au/water-foragriculture/taking-and-using-water/compliance-reports/water-compliancereport-2021-22. Accessed 25 June 2023.

[1832] Department of Environment, Land, Water and Planning (DELWP) 2015, 'Compliance Report 2021-22', https://www.water.vic.gov.au/water-for-agriculture/taking-and-using-water/compliance-reports/water-compliance-report-2021-22, Accessed 25 June 2023.

[1833] Pearson D 2020, 'Compliance and Enforcement Review: DELWP and delegated water corporations' responsibilities within the Water Act 1989. Summary Overview Report', Prepared for Minister for Water.

[1834] Neville L 2020, 'Zero tolerance to water theft in Victoria', Media release, Minister for Water, 7 September 2020.

[1835] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Central and Gippsland region sustainable water strategy', Melbourne, Victoria.

[1836] Ibid.

Inland waters — Water resources

> ‘Environmental water recovery targets have been developed that reflect a balance between meeting critical environmental outcomes and affordable water bills without taking water away from other users. Over the next 10 years, a total of up to 99.5 gigalitres of water will be returned to the environment in major rivers in the Central and Gippsland Region. Water will be recovered for the environment through infrastructure upgrades, local opportunities to use recycled water and stormwater, instead of river water, for non-drinking uses, and by moving water more effectively around Victoria’s water grid. Water will not be taken away from farmers, and all existing water entitlements provided under the Water Act will be protected.’ [1837]

The Central and Gippsland Region Sustainable Water Strategy has also proposed reallocations of the water resource for the environment in the catchments of the main rivers in the region. These are summarised in Table WR10, which shows that the current total environmental entitlement (76.1 GL/year) will be increased by 99.5 GL/year (see column with new 10-year environmental targets) to 175.6 GL/year. The total environmental need (current entitlement plus current environmental deficit) of the region’s rivers is 456.4 GL/year. The gap between that need and the new 10-year targets for the return of water to the rivers would be 280.8 GL/year (456.4 less 175.6). The reduced gap will ease the stress on rivers; however, environmental deficits remain across the region and will be exacerbated by the reduced stream flows associated with climate change.

Table WR10: Current environmental entitlement, environmental deficit and new environmental target for the Central and Gippsland Region.[1838]

River	Current environmental entitlement (GL/year)	Current environmental deficit (GL/year)	New 10-year environmental target (GL/year)
Barwon River	1	29	5
Moorabool Yulluk (Moorabool River)	2.5	17	7.2
Wirribi Yaluk (Werribee River)	2.6	12	12
Mirrangbamurn (Maribyrnong River)	0	7	7
Birrarung (Yarra River)	17	34	11
Bunyip and Tarrago rivers	3	1.3	1.3
Carran Carran (Thomson River)	18	80	15
Wirn Wirndook Yeerung (Macalister River)	14	39	12.6
Durt-Yowan (Latrobe River)	18	129	15 (7-year target)
Tyers River	0	32	13.4
Totals	76.1	380.3	99.5

[1837] Department of Environment, Land, Water and Planning (DELWP) 2022, ‘Central and Gippsland region sustainable water strategy’, Melbourne, Victoria.

[1838] Ibid.

Inland waters — Water resources

Satisfying all water users and the environment will be challenging and place pressure on the system for water entitlements and allowable levels of take. For example, in the Mildura area there has been a rapid expansion of water-intensive almond plantations where the area used for almonds increased by 15,000 ha (50%) between 2016 and 2019.[1839] The almond producers can buy water from elsewhere in the Murray-Darling Basin, which must then be supplied to the farm by water authorities. For the Murray-Darling, this could require higher summer flows through the Barmah Choke, a narrow section of the river in the Barmah-Millewa Forest and part of the Barmah Forest Ramsar Site. To prevent unseasonal flooding of the forest and protect its values, water authorities maintain lower flows through the Barmah Choke in summer. Rapidly expanding water demand, and the water trading used to satisfy it, could undermine that management objective.

With the closure of the Hazelwood Power Station in 2017, the company that owns the site, Engie, has proposed the filling of the associated open-cut coal mine with groundwater from local aquifers and surface water from the Latrobe River as part of its rehabilitation works. It could take between 10 and 20 years to fill the mine pit along with a maximum of 24.5 GL of surface water during the filling process. This is in addition to 17.9 GL of groundwater each year for its use as well as an annual need of 5 ML to replace water lost to evaporation.[1840] The proposed volumes of water needed to fill the pit would place great pressure on a region's water resources that are already under stress, along with contamination of the water by heavy metals in the coal ash left at the site. The proposal to fill the lake is now the subject of an Environmental Effects Statement under the Environment Protection and Biodiversity Conservation Act 1999.

The Blue Rock Dam was constructed on the Tanjil River near Moe to provide cooling water for the Latrobe Valley's thermal power stations. With their announced closure over the next 20 years, the dam's water resource and the water held in reserve by the Victorian Government to support the operations of the power stations, will be reallocated to other needs. The Central and Gippsland Region Sustainable Water Strategy commits to reallocate two-thirds of the 25 GL held in reserve to environmental flows in the Latrobe Valley by 2024, 'to support cultural values and self-determined outcomes for Gunaikurnai Traditional Owners', and irrigation.' [1841] The share to each use is yet to be determined. The sustainable water strategy also raises the option of a pipeline from the Blue Rock Dam to the Latrobe Valley.

Climate change will also influence the volume of surface water and water allocations. A stress test of the Goulburn River by John et al. (2021) found that, for moderate emissions scenarios, climate change:

> 'causes severely low water allocations in the system, large environmental water shortfalls and leads to worse outcomes for most ecological endpoints in the river system regardless of adaptation attempts. This suggests that river managers should be prepared for potentially inevitable transitions in regulated river ecosystems unless aggressive climate change mitigation efforts are pursued.' [1842]

[1839] Davies A 2019, 'Tough nut to crack: The almond boom and its drain on the Murray-Darling', *The Guardian*, 26 May 2019.

[1840] Schapova N 2022, 'Hazelwood mine rehabilitation plan to be assessed amid environmental concerns', *ABC Gippsland*, 23 February 2023.

[1841] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Central and Gippsland region sustainable water strategy', Melbourne, Victoria.

[1842] John A, Horne A, Nathan R, Fowler K, Webb J, Stewardson M 2021, 'Robust climate change adaptation for environmental flows in the Goulburn River, Australia', *Frontiers in Environmental Science*, 9, https://doi.org/10.3389/fenvs.2021.789206 Accessed 23 June 2023.

Inland waters — Water resources

Indicator WR:05 Water recycling

WR:05 Water recycling						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🟡	↙	🟢	🟡	↗	🟢
Data source(s):	DELWP					
Measure(s):	Volume and percentage of wastewater recycled					

Why this indicator?

Recycled water is largely independent of rainfall and can be a reliable source of water in an uncertain climate. It is suitable for a wide range of uses, helps reduce pressure on water resources, makes cities and towns more resilient and can provide water for delivery to wetlands and waterways.

NB: This SoE 2023 indicator was 'WR:08 Water recycling' in the SoE 2018 Report.

Why this assessment in 2023?

The production of recycled water varies due to fluctuating demand, variable weather patterns and the volume of wastewater produced. Over the 5-year period from 2016–17 to 2020–21, the percentage of wastewater recycled ranged from 17% to 22% and then back to 17%, with an associated reduction in the volume of recycled water.

Summary of State of the Environment 2018 Report assessment

- Farmers and irrigators were the largest users of recycled water in the state.
- Approximately 60% to 70% of all wastewater produced in Victoria was discharged to the ocean each year, while up to 20% was discharged to inland waterways. The remaining wastewater produced in Victoria was recycled.
- The volume of water recycled in Melbourne in 2015–16 represented 12% of the total wastewater produced in Melbourne. The remainder of the state recycled 31% of the wastewater available for re-use in 2015–16.

Critical data used for the 2023 assessment

- Supplying and Using Recycled Water
- Annual Victorian Water Accounts Reports

2023 assessment

As climate change and population growth places greater pressure on Victoria's water resources, the use of recycled water is being seen as one option for filling shortfalls in supply. Recycled water is categorised as either:

- Class A: non-drinking purposes, such as toilet flushing, garden watering, car washing, filling ponds and water features, livestock drinking, and firefighting
- Class B: agricultural (e.g. dairy cattle grazing) and industrial use (e.g. washdown water)
- Class C: irrigation of pasture for livestock, watering of municipal parks and gardens, golf courses, and dust control.

In Victoria, recycled water cannot be used for drinking, cooking and other kitchen uses, bathing, showering or the filling of pools and spas.[1843]

[1843] Barwon Water, 'Class A recycled water in "purple pipe" areas' https://www.barwonwater.vic.gov.au/water-and-waste/recycled-water/class-a Accessed 5 September 2022.

Inland waters — Water resources

Following several years when the volume of wastewater had been declining and the volume of recycled water was relatively stable, in 2008 the Victorian Government established a target of 20% of wastewater to be recycled. However, since the release of that policy, the volume of wastewater produced has increased, while the volume of recycled water has remained stable. This is shown in Figure WR50, which charts wastewater production and recycled water between 2004-05 and 2020-21. In 2019-20, 16% of wastewater produced was recycled which increased to 17% by 2020-21.

The Victorian Auditor-General's Office (VAGO) released an assurance report on the supply and use of recycled water in November 2021.[1844] Based on data in the annual Victorian water accounts, VAGO found that:

> 'Recycled water use has not increased over the last decade.' [1845]
>
> 'Many Victorians have a limited understanding of water security and the risks and benefits of using recycled water.' [1846]
>
> 'But there are also some known and potential regulatory, economic and physical barriers to recycled water uptake that can be addressed.' [1847]
>
> 'Responsible agencies are actively engaging with the community to understand risks and opportunities for recycled water. They are also working together to identify and deliver water recycling projects.' [1848]

Table WR11 shows that, in 2020-21, 83% of the 512 GL of wastewater produced was discharged to the oceans and the environment, with only 17% being recycled. Of the 87 GL of recycled water produced by water corporations, just under 49% was used for agriculture, nearly 23% was used for urban and industrial use, 15% used within water corporation processes and 12% was used for the benefit of the environment. There are, however, risks associated with the use of recycled water for boosting environmental flows in waterways or for recharging aquifers. Without proper treatment, the water can contain per- and poly-fluoroalkyl substances (PFAS; manufactured chemicals that resist heat, oil and water), micro-plastics, nutrients, pesticides, heavy metals and pharmaceuticals, which can harm aquatic life and pose hazards to human health.[1849, 1850, 1851, 1852]

[1844] Victorian Auditor-General's Office (VAGO) 2021, 'Supplying and using recycled water', Melbourne, Victoria.

[1845] Ibid.

[1846] Ibid.

[1847] Ibid.

[1848] Ibid.

[1849] Zabo D, Coggan T, Robson T, Currell M, Clarke B 2018, 'Investigating recycled water use as a diffuse source of per- and polyfluoroalkyl substances (PFASs) to groundwater in Melbourne, Australia', *Science of the Total Environment*, 10(644), pp. 1409-1417, doi: 10.1016/j.scitotenv.2018.07.048.

[1850] Water Research in Australia, 'Microplastics in potable and recycled water', https://www.waterra.com.au/project/microplastics-in-potable-and-recycled-water/ Accessed 15 March 2023.

[1851] Recycled Water in Australia, 'What are the potential risks associated with recycle water?', http://www.recycledwater.com.au/index.php?id=69 Accessed 15 March 2023.

[1852] Rodríguez C, Taylor P, Devine B, Van Buynder P, Weinstein P, Cook A 2012, 'Assessing health risks from pesticides in recycled water: A case study of augmentation of drinking water supplies in Perth, Western Australia', *Human and Ecological Risk Assessment: An International Journal*, 18(6), pp. 1216-1236, DOI:10.1080/10807039.2012.725365 Accessed 23 June 2023.

Inland waters — Water resources

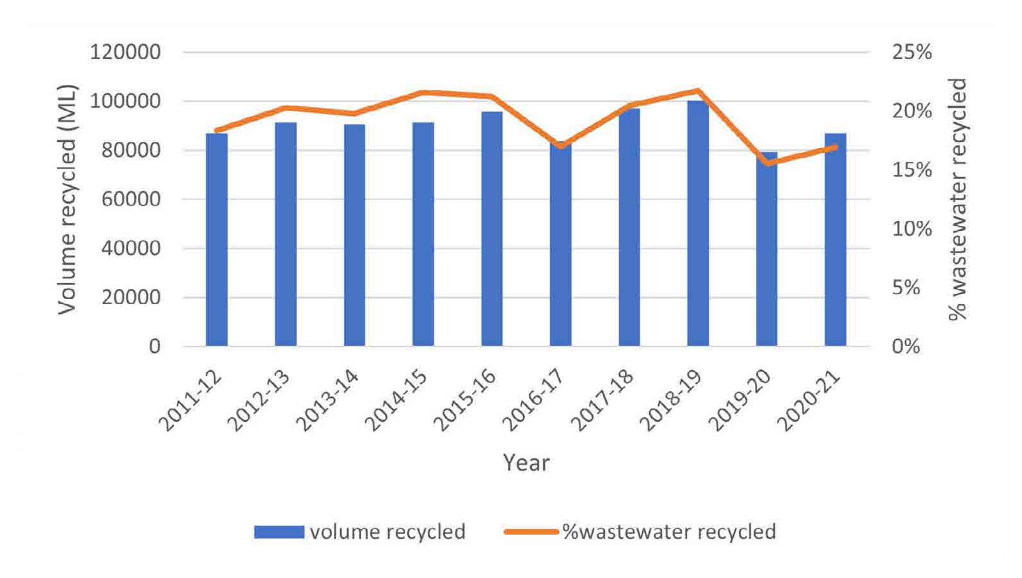


Figure WR50: Volume of wastewater produced and recycled in Victoria from 2011-12 to 2020-21.[1853]

Table WR11: Recycled water availability and use from 2016-17 to 2020-21.[1854, 1855, 1856, 1857, 1858]

Consumption type	2016-17	2017-18	2018-19	2019-20	2020-21
Wastewater produced (GL)	493,601	474,881	461,285	510,583	512,667
Wastewater recycled (GL)	83,811	97,159	100,342	79,389	86,959
Percent recycled (%)[1]	17	20	22	16	17
Urban and industrial (GL)	19,911	25,951	25,182	19,699	19,668
Agriculture (GL)	37,754	44,325	51,740	41,825	42,419
Beneficial allocation (GL)[2]	7,628	8,032	6,922	5,552	10,428
Within process (GL)[3]	18,517	18,850	16,490	12,313	13,021
Discharged to the environment (GL)	50,915	41,548	38,655	47,004	54,616
Release to ocean/other (GL)	358,876	336,177	322,288	384,190	372,566

[1] *The percentage of wastewater recycled includes water recycled 'within plant process', which refers to water reused in treatment processes. This treatment is consistent with the Essential Service Commission's performance report.*
[2] *Volume used to deliver specific environmental flow benefits.*
[3] *Water reused in wastewater treatment processes, for example to backflush filters. This value is included in the total percentage recycled.*

Table WR12 presents data on the targets and results for effluent re-use in each of Victoria's water corporations. The targets vary and the results are mixed. Of the 15 corporations that recycle wastewater, nine failed to reach their 2021-22 targets, with as much as 49% negative variance from the targets.

1853. Department of Environment, Land, Water and Planning (DELWP), 'Unpublished data', Melbourne, Victoria, Accessed 2022.
1854. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2016-17', Melbourne, Victoria.
1855. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2017-18', Melbourne, Victoria.
1856. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2018-19', Melbourne, Victoria.
1857. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian water accounts 2019-20', Melbourne, Victoria.
1858. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.

Inland waters — Water resources

The reasons given by the water corporations for the negative variances included reduced demand from agricultural, urban and industrial users during wet and dry summers, increased volume of stormwater and sewage needing treatment, and technical problems at recycling treatment facilities. Those corporations reporting positive variances from targets cited hot and dry summers that increased demand from agricultural and urban users and the expansion of wastewater recycling facilities.

Table WR12: Effluent re-use targets and results for Victoria's water corporations in 2021-22.[1859, 1860, 1861, 1862, 1863, 1864, 1865, 1866, 1867, 1868, 1869, 1870, 1871, 1872, 1873]

Water Corporation	Effluent re-use target 2021-22 (%)	2021-22 Result (%)	Variance from target (%)
Greater Western Water	54.0	34.4	-36.3
South East Water	30.0	26.0	-13.3
Yarra Valley Water	>25	29.3	17.2
Barwon Water	20.0	10.2	-49.0
Central Highlands Water	15.0	15.2	1.3
Coliban Water	39.0	25.2	-35.5
East Gippsland Water	100	99.7	-0.3
Goulburn Valley Water	70	66.0	5.7
Gippsland Water	25.0	26.8	7.2
Goulburn-Murray Water	Does not treat or manage wastewater		
Grampians Wimmera Mallee Water	80.0	98.0	22.5
Lower Murray Water	60.0	52.5	-12.6
North East Water	32.0	20.9	-34.7
South Gippsland Water	4.0	4.2	5.0
Southern Rural Water	Does not treat or manage wastewater		
Westernport Water	>25.0	17.9	-28.4
Wannon Water	20.0	17.7	-11.5

The use of recycled water for agriculture and urban parks, playing fields and gardens is influenced by weather, with wetter summers reducing demand. The result is a fluctuating demand for recycled water each year, creating some uncertainty for its producers. This uncertainty could be reduced by supplying recycled water for urban uses that are less sensitive to climate and do not require potable water (e.g. residential and non-residential toilet flushing and outdoor uses) in both growth and redevelopment areas.

There are several projects that will increase the demand for recycled water and could provide greater certainty for its producers. A volume-based, time-bound recycled water use target of 85,000 ML/year by 2030 and 230,000 ML/year by 2050 has been developed by partner organisations of the Greater Melbourne Integrated Water Management Forums. The target was determined by largely considering emerging potential urban and agricultural uses in the region over the next 30 years. The Hinterland Environmental Water Scheme has been proposed as a way to reduce the volume of wastewater discharged to the ocean at Gunnamatta on the Mornington Peninsula by diverting it for use in agriculture and public open spaces.[1874] Another waste-water diversion project is the Tyabb/Somerville recycled water scheme.

1859. Coliban Water 2022, 'Annual report 2021-22', Bendigo, Victoria.
1860. East Gippsland Water 2022, 'Annual report 2021-22', Bairnsdale, Victoria.
1861. Gippsland Water 2022, 'Annual report 2021-22', Traralgon, Victoria.
1862. Goulburn Valley Water 2022, 'Annual report 2021-22', Shepparton, Victoria.
1863. Grampians Wimmera Mallee Water 2022, 'Annual report 2021-22', Horsham, Victoria.
1864. Lower Murray Water 2022, 'Annual report 2021-22', Mildura, Victoria.
1865. North East Water 2022, 'Annual report 2021-22', Wodonga, Victoria.
1866. South Gippsland Water 2022, 'Annual report 2021-22', Foster, Victoria.
1867. Westernport Water 2022, 'Annual report 2021-22', Newhaven, Victoria.
1868. Wannon Water 2022, 'Annual report 2021-22', Warrnambool, Victoria.
1869. Greater Western Water 2022, "Annual report 2021-22', Sunbury, Victoria.
1870. South East Water 2022, 'Annual report 2021-22', Frankston, Victoria
1871. Yarra Valley Water 2022, 'Annual report 2021-22', Mitcham, Victoria.
1872. Barwon Water 2022, 'Annual report 2021-22', Geelong Victoria.
1873. Central Highlands Water 2022, 'Annual report 2021-22', Wendouree, Victoria.
1874. Mornington Peninsula Shire, 'Hinterland environmental water scheme' https://shape.mornpen.vic.gov.au/hinterland-environmental-water-scheme Accessed 4 September 2022.

Inland waters — Water resources

Indicator WR:06 Percentage of agricultural land with improved irrigation

WR:06 Percentage of agricultural land with improved irrigation

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	●	↗	●	●	?	🔴
Data source(s):	CMAs					
Measure(s):	Percentage of agricultural land with improved irrigation infrastructure Efficiency of water use Water recovery outcomes					

Why this indicator?

Improving irrigation practice, such as developing crops that require less water and making irrigation practices and equipment more efficient, can significantly benefit the environment by increasing water recovery and providing opportunities to enhance flow regimes.

NB: This SoE 2023 indicator was ‘WR:09 Percentage of agricultural land with improved irrigation’ in the SoE 2018 Report.

Why this assessment in 2023?

Current data are not reflective of irrigation improvements made by irrigators without government assistance. There are data on overall investment improvements to irrigation districts; however, they are not at the farm level. Both the Australian and Victorian governments are investing heavily in the modernisation of irrigation for agriculture. This will result in improvements to on-farm irrigation in terms of water efficiency and water recovery. Environmental outcomes are less clear. Analysis is difficult because the use of water for irrigation fluctuates from year to year due to weather conditions and economics.

Summary of State of the Environment 2018 Report assessment

- Approximately 27,000 hectares of agricultural land were upgraded with improved irrigation from 2013–14 to 2016–17, which was less than 3% of Victoria’s total area of irrigated agriculture.
- More than 90% of the irrigation infrastructure improvements were in the Goulburn Broken catchment.
- Data were severely limited on irrigation improvements.

Critical data used for the 2023 assessment

- Available data at the farm level are currently limited for the assessment.

2023 assessment

Victoria’s irrigated agriculture sector is concentrated in 14 irrigation districts and is the state’s largest user of water. Although there are irrigation districts on the Macalister River and at Werribee, 10 of the irrigation districts are along the Murray River between Shepparton and Mildura. Table WR13 provides data on Victorian sources and uses of irrigation water in 2020-21 and shows that, although irrigation of fruit, vegetables and vines covered the greatest land area, pastures and cereal crops received the largest volumes of water.

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Table WR13: Water source and water use for irrigation in Victoria 2020-21.[1875]

Water Source	Water use for agriculture (ML) 2020-21
Water Source	
Total volume of water from all sources (ML)	1,700,120
Water taken from irrigation channels or irrigation pipelines (ML)	1,068,825
Water taken from on-farm dams or tanks (ML)	38,417
Water taken from rivers, creeks, lakes, etc. (ML)	320,223
Groundwater (e.g. bores, springs, wells) (ML)	217,506
Recycled/re-used water from off-farm sources (e.g. re-use schemes, mines) (ML)	46,510
Town or reticulated mains supply (ML)	8,037
Other sources of water (excluding rainfall) (ML)	602
Water use	
Total area watered (ha)	490,112
Total volume applied (ML)	1,642,701
Pastures (including lucerne) and cereal crops used for grazing or fed off - Area watered (ha)	233,657
Pastures (including lucerne) and cereal crops used for grazing or fed off - Volume applied (ML)	674,466
Pastures (including lucerne) and cereal crops cut for hay and silage - Area watered (ha)	85,122
Pastures (including lucerne) and cereal crops cut for hay and silage - Volume applied (ML)	233,558
Vegetables - Area watered (ha)	231,771
Vegetables - Volume applied (ML)	76,204
Fruit trees, nut trees, plantation or berry fruits - Area watered (ha)	57,030
Fruit trees, nut trees, plantation or berry fruits - Volume applied (ML)	398,181
Grapevines - Area watered (ha)	26,959
Grapevines - Volume applied (ML)	125,430
Nurseries, cut flowers and cultivated turf - Area watered (ha)	3,741
Nurseries, cut flowers and cultivated turf - Volume applied (ML)	12,308
Cereals for grain or seed, excluding rice - Area watered (ha)	46,735
Cereals for grain or seed, excluding rice - Volume applied (ML)	92,666

Based on data from the CMAs of Goulburn-Broken, Mallee and West Gippsland (the three CMAs that reported irrigation improvements in their annual reports), the total area of improved irrigation from 2016-17 to 2020-21 (Table WR14) was 23,264 hectares (~4.7% of the state's irrigated agriculture of 490,112 hectares in 2020-21), while between 2014-15 and 2020-21 it was 40,143 hectares, representing approximately 8.2% of Victoria's area of irrigated agriculture. Irrigation infrastructure improvements include laser levelling, soil moisture monitoring and pressurised irrigation systems (micro or drip plus sprinkler). There are no publicly available data on the outcomes for water-use efficiency from these infrastructure improvements.

1875. Australian Bureau of Statistics, 'Water use on Australian farms 2020-21' https://www.abs.gov.au/statistics/industry/agriculture/water-use-australian-farms/latest-release Accessed 26 February 2023.

Inland waters — Water resources

Table WR14: Irrigation infrastructure improvement works (ha) in the Goulburn Broken, Mallee and West Gippsland CMAs.[1876, 1877, 1878, 1879, 1880, 1881, 1882]

CMA	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Goulburn Broken (ha)	4,745	3,713	4,455	5,174	2,538	7,790	4,947	719
Mallee (ha)	275	1,168	462	597	765	599	159	0
West Gippsland (ha)	103	130	153	228	555	237	604	27.16
Total (ha)	5,123	5,011	5,070	5,999	3,858	8,626	5,710	746

Water-use efficiency data at the irrigation-district scale is based on the supply system and not the level of use at the farm scale. There is no single, comprehensive data set providing information on the efficiency of on-farm irrigation, infrastructure upgrades, improvements to irrigation practices or similar. It is unlikely that, in the short-term, an ongoing and reliable data source will be available to assess all on-farm irrigation improvements in Victoria due to the high costs and other resource constraints. DEECA's Sustainable Irrigation Program supports property planning and provides independent advice to irrigators and grants.

The DEECA Rural Water Policy and Program undertakes the Regional Irrigation Land and Water Use Mapping Program. It looks at water and land-use trends in priority irrigation areas, including Sunraysia, the Goulburn Murray Irrigation District and the Macalister Irrigation District. A 2019-20 survey of 134 irrigators in the Goulburn Murray District, as part of the mapping program, found that 93% that are connected to the main channel system had modernised supply points, and of those, 62% had improved their irrigation management.[1883] The survey also found that 80% had upgraded their on-farm irrigation infrastructure. The upgrades included laser grading, water reuse systems and automation, with 41% receiving either State or Commonwealth funding to do so. Survey respondents indicated that the three main barriers to further improvements in irrigation management were uncertainty of water allocation, lack of financial resources and inadequate water availability.

Although some irrigators are improving their irrigation operations, most of the investment has been by State and Commonwealth governments and water corporations to improve irrigation-district delivery efficiency and productivity. In Victoria, a number of infrastructure projects, either underway or completed, have been funded by the State, Commonwealth and water corporations in recent years. This includes the Connections Project, Goulburn-Murray Water — Water Efficiency Project, the Macalister Irrigation District MID2030 Modernisation Project and the Werribee Irrigation District Modernisation project.

The Victorian Government's Connections Project exceeded its original water recovery target of 429 GL by 4 GL. Of the 433 GL of water recovered through irrigation modernisation, 279 GL has been recovered for the environment, 77.68 GL of water recovery was distributed to Goulburn Murray irrigators as an increased water share or as a financial payment, and 1.36 GL was set aside for Traditional Owners.[1884]

1876. Victorian Catchment Management Authorities (CMAs) 2015, 'Action and achievements report 2014-15', Melbourne, Victoria.
1877. Victorian Catchment Management Authorities (CMAs) 2016, 'Action and achievements report 2015-16', Melbourne, Victoria.
1878. Victorian Catchment Management Authorities (CMAs) 2017, 'Action and achievements report 2016-17', Melbourne, Victoria.
1879. Victorian Catchment Management Authorities (CMAs) 2018, 'Action and achievements report 2017-18', Melbourne, Victoria.
1880. Victorian Catchment Management Authorities (CMAs) 2019, 'Action and achievements report 2018-19', Melbourne, Victoria.
1881. Victorian Catchment Management Authorities (CMAs) 2020, 'Action and achievements report 2019-20', Melbourne, Victoria.
1882. Victorian Catchment Management Authorities (CMAs) 2021, 'Action and achievements report 2020-21', Melbourne, Victoria.
1883. Goulburn-Broken Catchment Management Authority (CMA) 2021, 'Regional irrigated land and water use mapping in the Goulburn-Murray Irrigation District 2019-20', Farm Irrigation Survey Technical Report 2021, Shepparton, Victoria.
1884. Department of Environment Land, Water and Planning (DELWP), 'Irrigators' share distribution', https://www.water.vic.gov.au/water-for-agriculture/irrigators-share-distribution Accessed 5 September 2022.

The project involved the decommissioning of 1,725 km of channels, remediation of 310 km of channels, the installation of 9,539 m in northern Victoria and a water delivery efficiency increase from 70% to 85% in the Goulburn Murray Irrigation District.[1885] Prior to the project's start, it was estimated that 900 GL of water was being lost in the Goulburn Murray irrigation network each year due to seepage, leakage, evaporation, meter error and unauthorised use. Each year water recovery is independently audited.

The efficient use of water in irrigation is a priority as water resources come under pressure from climate change, population growth and increasing competition. The Commonwealth Government's On-Farm Irrigation Efficiency program ran from 2009 to 2019 and funded more than 1,500 projects across Australia to improve on-farm water use.[1886] Projects included the installation or upgrading of infrastructure and equipment and improvements in farm layout. Those funded in Victoria were largely concentrated between Swan Hill and Echuca.

Grafton et al. (2018) contend that increasing the efficiency of water use for irrigation rarely reduces water consumption.[1887] For example, irrigators might increase the area of crops to be irrigated rather than reduce water consumption.[1888] Increased efficiency might also reduce groundwater recharge due to there being less water applied to the agricultural land. However, in areas of elevated groundwater risk (e.g. salinity and water logging), there can be environmental benefits. Irrigators also use water savings to reduce reliance on the temporary water market and/or increase resilience against dry periods, heatwaves or low allocations.

Southern Rural Water has been conducting feasibility studies into the development of irrigated agriculture for:

- dairy and fodder production on 30,000 hectares on the regulated Latrobe River (between Yallourn and Longford)
- vegetable growing, primarily on 6,000 hectares along the catchments of the Macalister and Avon rivers.

It is projected that water demand would peak at 20,000 ML/year for the Latrobe River area and 10,000 ML/year for the Avon River area. It has been suggested that a reallocation of water entitlements would be required for the Latrobe River development, while water savings from improvements in the Macalister Irrigation District could be used to supply water for development along the catchments of the Macalister and Avon rivers.[1889] Both rivers are within the catchment of the Gippsland Lakes Ramsar site, which could be impacted by changes in the stream flows of the rivers that discharge into them. Southern Rural Water is assessing the feasibility of these options in consultation with stakeholders and in accordance with the Central and Gippsland Region Sustainable Water Strategy.

1885. Goulburn-Murray Water, 'Connections project', https://www.g-mwater.com.au/policy-and-projects/connectionsproject Accessed 15 August 2022.
1886. Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'On-farm irrigation efficiency program' https://www.dcceew.gov.au/water/policy/programs/completed/ofiep Accessed 15 August 2022.
1887. Grafton Q, Williams J, Perry C, Molle F, Ringler C, Steduto P, Udall B, Wheeler S, Wang Y, Garrick D, Allen R 2018, 'The paradox of irrigation efficiency', *Science*, 361(6404).
1888. Ibid.
1889. RMCG, GHD 2021, 'Southern Victoria irrigation development project phase 3, consolidated final report', Bendigo, Victoria.

Inland waters — Water resources

Indicator WR:07 Groundwater levels, consumption and use

WR:07 Groundwater levels, consumption and use

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	→ (most shallow aquifers) ↙ (shallow aquifers in northern region; lower aquifers in Gippsland and northern region)	🟢	🟡	→	🟢

Data source(s):	DELWP
Measure(s):	Groundwater levels for shallow, middle and lower aquifers Groundwater consumption as a percentage of total entitlementa

Why this indicator?

Trends in groundwater levels can be used to monitor the impact of extraction, land-use change and climate change.

NB: This modified SoE 2023 indicator has been formed by merging the SoE 2018 indicators 'WR:12 Groundwater levels' and 'WR:13 Groundwater harvested for consumptive use'. The 2018 assessment provided in this report card is for 'WR:13 Groundwater harvested for consumptive use', as its measure is most comparable to that of the modified 2023 indicator.

Why this assessment in 2023?

For the 5-year trend from 2016–17 to 2020–21, shallow (unconfined) aquifers are largely stable, except in the northern region. For middle and lower (confined) aquifers, some in the Gippsland Basin and northern Victoria are declining. In the longer term, groundwater levels generally are expected to decline. Data on the outcomes of this long-term change are limited. Caution needs to be applied when determining the statewide status because it averages across a large number of aquifers, each of which has different characteristics and can be connected to other aquifers that are not monitored.

Summary of State of the Environment 2018 Report assessment

- Groundwater levels in shallow aquifers mostly remained stable during the SoE 2018 reporting period, except for a small number of areas where declines were observed.
- Declines in deep-groundwater levels generally had little or no impact on environmental features at the surface.
- In southern Victoria, declines in lower aquifers related to mining activities were occurring in the Gippsland Basin. Smaller declines had also been observed in confined aquifers around Westernport and the Otway Ranges.
- In northern Victoria, groundwater levels had declined in recent years due to periods of low rainfall and groundwater extractions.
- Nearly half of the state's licensed groundwater use occurred in northern Victoria. The other regions with large extraction volumes were Gippsland, and the south-west of the state.

Critical data used for the 2023 assessment

- DELWP updated groundwater data and maps

Inland waters — Water resources

2023 assessment

Groundwater is formed when rainfall seeps into the soil and down into rock formations where the water is stored in porous sands, cracks and crevices. These underground water storages or aquifers can either be shallow (less than 40 m in depth) or deep (greater than 40 m in depth). Groundwater levels are the balance between inflows (recharge) and outflows (discharge).

Shallow aquifers can rise during and after rain and fall due to drought or extraction for such uses as urban and rural drinking water and crop irrigation. Middle and lower aquifers are less affected by wet and dry periods. However, their levels can also be reduced by extraction. In the longer term, groundwater levels, especially shallow aquifers, will be impacted by the reduced rainfall associated with climate change. At the same time, the reduced availability of surface water due to climate change could lead to pressures on groundwater resources as a result of increased demand.

Due to the location of the groundwater reserves, only three of Victoria's 18 water corporations — Goulburn-Murray Water, Grampians Wimmera Mallee and Southern Rural Water — are currently tasked with their management under the Victorian *Water Act.* Licensed groundwater use is metered for annual takes of greater than 10 ML or 20 ML (depending on the water corporation). Stock and domestic take is not metered or assessed. Table WR15 provides data on the volumes of water consumed by the four main users of groundwaterbetween 2016-17 and 2020-21. Irrigation is by far the largest user of groundwater, representing from 76% to 87% of total groundwater consumption.

Table WR15: The main uses of groundwater from 2016-17 to 2020-21.[1890, 1891, 1892, 1893, 1894]

Use	2016-17	2017-18	2018-19	2019-20	2020-21
Irrigation (ML)	267,716	362,518	433,109	372,016	312,428
Percent of total consumption (%)	76	83	87	85	83
Domestic and stock (ML)	47,465	45,444	31,716	32,307	31,152
Percent consumption (%)	13	10	6	7	8
Power generation (ML)	26,667	22,958	23,828	23,094	25,229
Percent of total consumption (%)	8	5	5	5	7
Urban (ML)	9,824	8,925	9,576	11,328	8,222
Percent of total consumption (%)	3	2	2	3	2
Total consumptive diversion (ML)	351,672	439,845	498,229	438,744	377,030

[1890] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2016-17', Melbourne, Victoria.
[1891] Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2017-18', Melbourne, Victoria.
[1892] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2018-19', Melbourne, Victoria.
[1893] Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian water accounts 2019-20', Melbourne, Victoria.
[1894] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.

Inland waters — Water resources

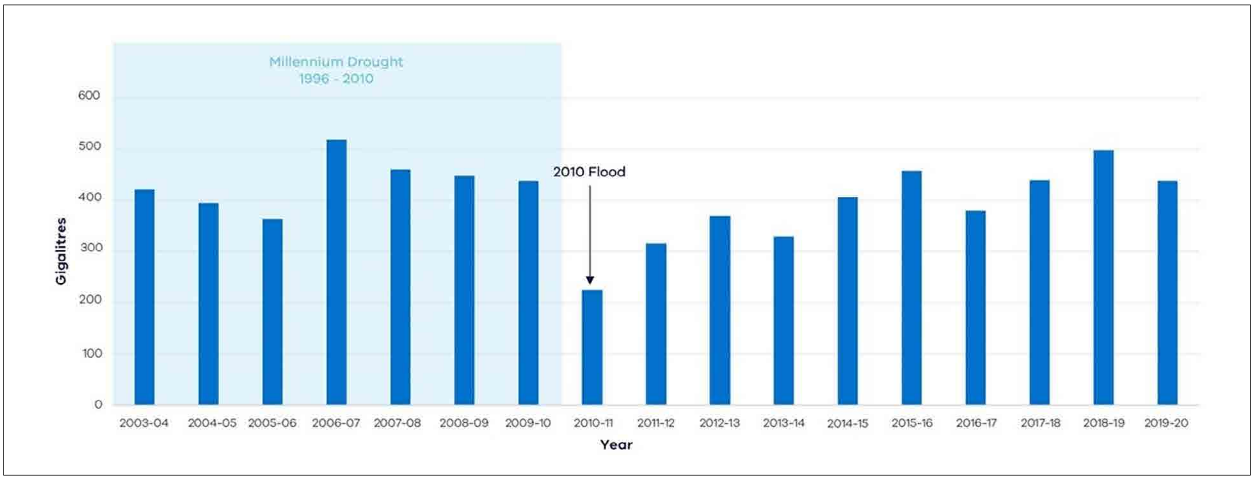


Figure WR51: Victorian groundwater consumption (GL) from 2003-04 to 2019-20.[1895]

Figure WR51 graphs groundwater consumption in Victoria from 2003-04 to 2019-20. It shows that groundwater consumption increased during the years of the Millennium Drought (2001-2009) and declined during the floods of 2010-11. Since then, the trend is for rising consumption. In 2020-21, 83% of groundwater consumed was used in irrigation/commercial/salinity control, 8% for stock and domestic, 7% for power generation and 2% in the urban sector.[1896]

The use of groundwater varies significantly across Victoria. In many areas, but especially in the west and south-west of the state, groundwater is the only water source for urban and agricultural use. High usage is concentrated in areas such as Gippsland and north-eastern and south-western Victoria. There the aquifers are of good quality and provide high yield, and the land is suited to its use — irrigation used 75% of the groundwater extracted in the state during 2020-21. Groundwater use is high in the Mid Loddon and Lower Campaspe Valley for shallow aquifers (unconfined) and Murrayville, Katunga, Giffard, Sale and Stratford for middle and deep (confined) aquifers.

Annual groundwater consumption can also vary from year to year due to the availability of surface water.[1897] Groundwater can be substituted for surface water during times when surface water levels are low. In total, 956,616 ML were available in 2020-21 and, of those, 377,032 ML (or 39.4%) was taken. In 2020-21, the Goulburn-Murray Basin had 48.2% of the available groundwater taken, and more than half of the groundwater available was taken in the state's north. A large amount of this take is in the Shepparton Irrigation Region, where use is estimated rather than metered. There is no limit on extractions, and use reflects the pumping of shallow groundwater to assist with salinity control. The annual percentage of the available groundwater taken in each of five groundwater catchment areas between 2016-17 and 2020-21 ranged from:

- Goulburn Murray Basin: 20% to 56.1%
- Gippsland basin: 22.8% to 43.8%
- Central Basin: 20.7% to 31.2%
- Otway-Torquay Basin: 4.3% to 31.4%
- Wimmera-Mallee Basin: 38.7% to 45.2%.[1898, 1899, 1900, 1901, 1902]

The state's groundwater reserves have been divided geographically into:

- five groundwater basins
- 20 groundwater catchments and groundwater management units (GMUS) that contain 44 groundwater management areas (GMAs)
- 16 water supply protection areas (WSPAs)
- two areas that are unincorporated (limited development).

1895. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Groundwater management 2030', Melbourne, Victoria.
1896. Ibid.
1897. The figures on groundwater pumping/use take account of all groundwater pumping including salinity water table control across the whole state.
1898. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2016-17', Melbourne, Victoria.
1899. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2017-18', Melbourne, Victoria.
1900. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2018-19', Melbourne, Victoria.
1901. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian water accounts 2019-20', Melbourne, Victoria.
1902. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.

The GMUs define areas where specific rules are needed to manage the groundwater resource. GMAs are reserves that have been or have the potential to be intensively developed and are subject to water entitlement caps. WSPAs are intensively developed and managed under groundwater management plans due to the risks of resource depletion. Unconfined GMAs are closer to the surface than confined GMAs, which are overlain by impermeable rock.

Of the 44 GMAs, the condition of 37 are stable, five is declining, and two have no bore to monitor and assess them. However, the 5-year trend from 2016-17 to 2021-22 has 21 GMAs that are stable, 12 declining, six rising, and three with an unclear trend. For the 14 WSPAs, the condition of 10 are stable, and four are declining, while in terms of trend, eight WSPAs are declining, five are stable and one is rising.

Figure WR52 (unconfined water table) and Figure WR53 (middle and deep confined aquifers) illustrate the link between groundwater levels and the consumption of groundwater. They map the five-yearly trend (2016-17 to 2020-21) in water levels in the GMUs (GMAs and WSPAs). The maps show the percentage of the permissible consumptive volume (PCV) taken over the same period. Historically, average licensed groundwater use was about 30% of total entitlement. During prolonged dry periods, such as the Millennium Drought, average groundwater use increases to approximately 50% of entitlement.[1903]

Water levels in the shallow aquifers were mostly stable, except for the Lower Ovens, Loddon Highlands as well as the Mid Loddon and Lower Campaspe Valley, which are areas of high use and in decline. Each of these four has had greater than 30% of its PCV extracted. A different geographical pattern exists for the confined aquifers, with Katunga and Murrayville, and those in Gippsland (e.g. Stratford, Sale and Giffard), showing declines in water levels. In these cases, the percentage of the PVC used has been greater than 46%, and in one case between 76% and 90%. The areas under the most stress, according to the water level trends, seem to be those areas with the highest proportion of use (PCV).

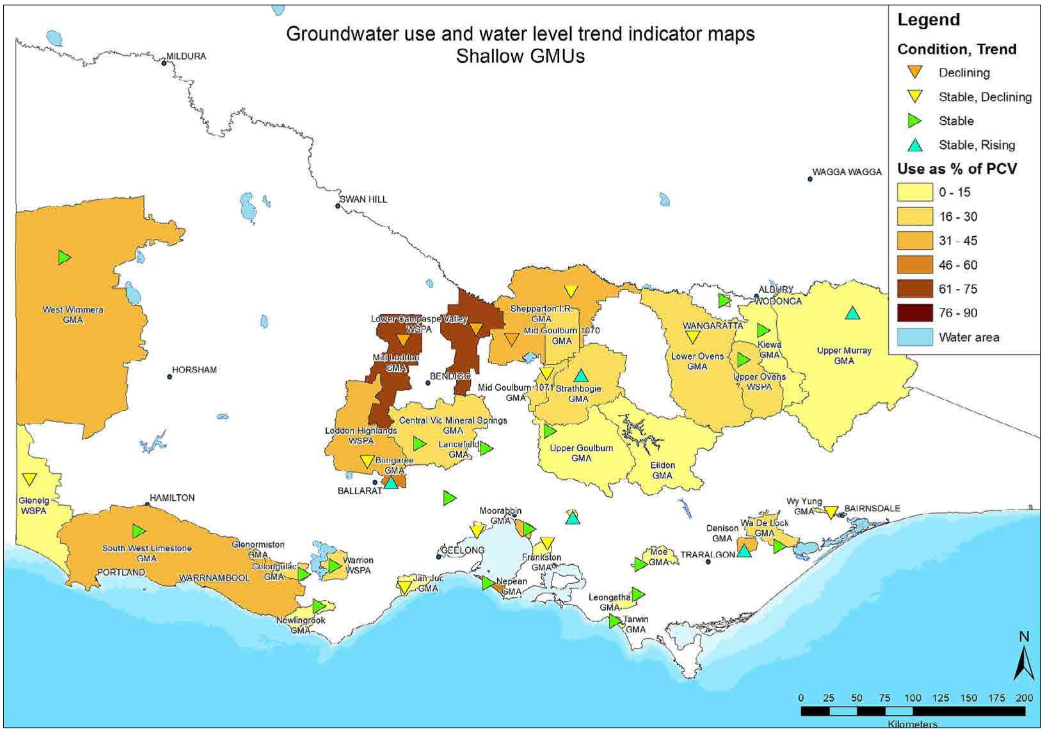


Figure WR52: Water level trends and five-yearly average (2016-17 to 2020-21) consumptive use for shallow GMUs in Victoria.[1904]

[1903] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.

[1904] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Unpublished data, Melbourne, Victoria, Accessed 2022.

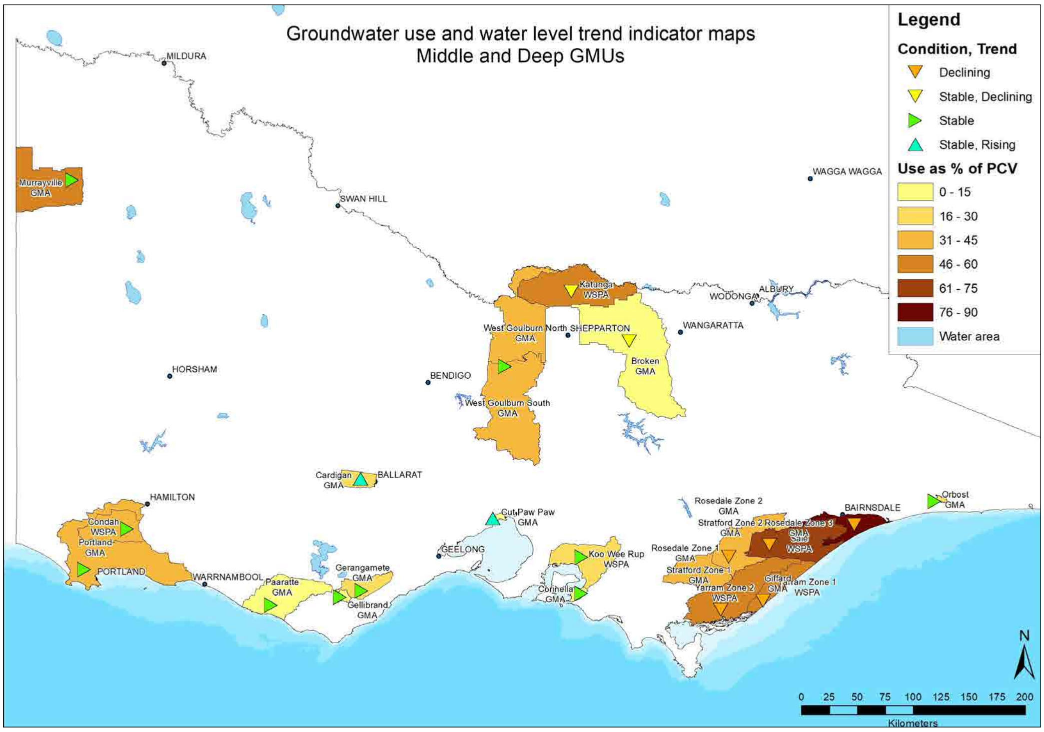


Figure WR53: Water level trends and five-yearly average (2016-17 to 2020-21) consumptive use for middle and lower (confined) GMUs in Victoria.[1905]

Table WR16 provides annual data on the available groundwater, entitlements for use and the volume and percentages of water taken for the four main uses — irrigation, urban and commercial, livestock and domestic, and power generation. The percentage of entitlement taken ranged from 36.2% to 51.6%, lower than those for surface water (see WR:04).

A review of Victoria's water accounts for the years 2017-18 to 2020-21 showed compliance with bulk entitlements across each of the 20 groundwater catchments. However, the entitlements have been set based on historical extractions rather than on an environmentally sustainable level of take.

Table WR16: Statewide groundwater available and taken from 2016-17 to 2020-21.[1906, 1907, 1908, 1909, 1910]

Volume and percentage	2016-17	2017-18	2018-19	2019-20	2020-21
Total Groundwater available (ML)	838,103	931,193	929,598	999,699	999,820
Total entitlements (ML)	971,575	967,100	965,641	948,037	948,278
Total taken (ML)	351,672	439,845	498,229	438,744	377,030
Percent of available groundwater taken (%)	42.0	47.2	53.6	43.9	37.7
Percent of entitlement taken (%)	36.2	45.5	51.6	46.3	39.8

1905. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Unpublished data, Melbourne, Victoria, Accessed 2022.
1906. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2016-17', Melbourne, Victoria.
1907. Department of Environment, Land, Water and Planning (DELWP) 2019, 'Victorian water accounts 2017-18', Melbourne, Victoria.
1908. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian water accounts 2018-19', Melbourne, Victoria.
1909. Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian water accounts 2019-20', Melbourne, Victoria.
1910. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-21', Melbourne, Victoria.

Rising groundwater levels would suggest that extraction is not exceeding recharge and that use is sustainable. However, rising levels could impact aquifers in areas at risk of salinity and/or land degradation, such as in the Shepparton and Macalister irrigation areas. They could also indicate that landscape-scale hydrologic imbalance is still occurring, and that increased groundwater recharge from poor land-use practices continues, especially if significant numbers of wet years occur. An expansion of irrigation areas could also cause the level of local saline groundwater to rise, potentially increasing saline discharges to surface water. Conversely, falling groundwater levels does not mean that groundwater condition is poor. Instead, it can indicate that the aquifer/groundwater system is approaching equilibrium or within operating limits.

Many ecosystems are dependent on groundwater to varying degrees (see 'B:03 Groundwater-dependent ecosystems'). For example, groundwater discharge contributes 24% to 36% of the stream flow in Gippsland's Avon River.[1911] Declining groundwater levels could have implications for groundwater-dependent ecosystems (GDEs), which rely, in part or completely, on groundwater for their functioning and persistence. They include subterranean waters, caves, wetlands, rivers, creeks and estuarine and nearshore marine ecosystems.[1912]

In time of drought, GDEs can act as refuges for animals and plants, and support the base flows of rivers and streams. Threats to GDEs include groundwater extraction, increasing levels of salinity and nutrients, and climate change.

Barwon Water had for some years, beginning during the Millennium Drought, extracted water from the aquifer beneath Boundary Creek and Big Swamp (a GDE). The swamp had been well-known locally for its fish, birdlife and platypuses. The drawdown exposed acid sulphate soils which polluted the swamp and caused a major fish kill along 30 km of the Barwon River.[1913] Barwon Water was ordered to remediate the damage to Big Swamp and withdrew its application for permission to continue extraction from the aquifer.

A set of priorities for the reform of groundwater management and licensing, GM2030, was released by DELWP in August 2022.[1914] GM2030 sets out 13 Priority Areas across three outcomes to achieve:

- an improved, shared understanding of groundwater and its uses for evidence-based management
- modern tools in the state-wide framework for flexible and cost-effective groundwater management
- streamlined and effective licensing, trade rules and controls on groundwater use that support changing water uses.

[1911] RMCG, GHD 2021, Southern Victoria Irrigation Development Project Phase 3, consolidated final report', Bendigo, Victoria.

[1912] Dresel P, Clark R, Cheng X, Reid M., Fawcett J, Cochraine D 2010, 'Mapping terrestrial groundwater dependent ecosystems: Method development and example output', Department of Primary Industries (DEPI), Melbourne, Victoria.

[1913] Neal M 2019, 'Barwon Water ordered to fix Otways water acidification due to pumping of key groundwater aquifer', *ABC South West Victoria*, 18 March 2019.

[1914] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Groundwater management 2030', Melbourne, Victoria.

Inland waters — Water resources

Water for the environment

This section contains the following indicator assessments:

- WR:08 Condition of flow regimes (within 'Environmental outcomes')
- WR:09 Delivering water for the environment (within 'Delivery and hydrology')

Accompanying the indicator assessments is a synthesis of relevant published material on environmental and community outcomes from water for the environment.

Indicator WR:08 Condition of flow regimes

WR:08 Condition of flow regimes

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴	→	🟢	🔴	↙	🟢

Data source(s):	DELWP
Measure(s):	Streamflow as a percentage of the long-term average

Why this indicator?

Low streamflow can have ecological impacts. The species that live in and around waterways rely on well-established flow patterns for successful foraging, breeding and movement throughout the landscape. Changes in streamflow patterns have cascading effects on the health of waterways and ecosystems that rely on groundwater.

Less water flowing in Victorian waterways increases the likelihood of more harmful algal blooms occurring that have the potential to affect the safety of Victoria's water supplies for drinking, supporting stock and for recreation.

NB: This SoE 2023 indicator was 'WR:03 Condition of flow regimes' in the SoE 2018 Report.

Why this assessment in 2023?

For many catchments in Victoria, the run-off response to rainfall has declined this century, particularly during the Millennium Drought. This means that, for a given amount of rainfall, Victoria's catchments have been getting less streamflow than in past decades

Because streamflow has been below the long-term average for most years this century, the status for this indicator has been assessed as poor. The trend has been rated as stable, because below-average streamflow was recorded in four of the five years for the SoE 2023 reporting period (2016-17 to 2020-21), which was the same as the previous five-yearly reporting period (2011-12 to 2015-16*).

** The SoE 2023 reporting period represents the years which data are available since the SoE 2018 Report as opposed to the 5-year SoE 2023 reporting cycle (2018-22). Data from 2022 for this indicator will be incorporated into the assessment for the SoE 2028 Report.*

Summary of State of the Environment 2018 Report assessment

- Streamflow, as a percentage of the long-term annual average streamflow, was below 100% in all regions as at 2015-16, with declines observed in all regions from 2011-12.

Critical data used for the 2023 assessment

- Streamflow data reported within the Victorian Water Accounts
- Climate Change – Trends and Extremes
- Victoria's Water in a Changing Climate

2023 assessment

Streamflow

Streamflow in Victoria is highly variable. Most years are generally dry and related to less flow, while the occasional very wet year leads to flows well above the average, replenishing storages and river systems.

The following factors impact on flow regimes:

- presence of dams and other barriers
- regulation of flow
- extraction of water for consumption
- channel modification
- changes in land use.

Since 2003-04, Victoria's annual streamflow peaked in 2010-11 and 2011-12, representing 202% and 144% of the long-term annual average streamflow, respectively. From then, up until the most recently available streamflow data (data from 2020-21), there has been below-average streamflow in eight of the nine financial years (Figure WR54), which coincides directly with eight of those nine years having below average rainfall (Figure WR58).

The average annual streamflow for Victoria for the most recent five years of data that have been included in this SoE 2023 Report (2016-17 to 2020-21) was 83% of the long-term average. This represents a slight deterioration from the previous 5-year period that was reported in the SoE 2018 Report (2011-12 to 2015-16), which was 90%.

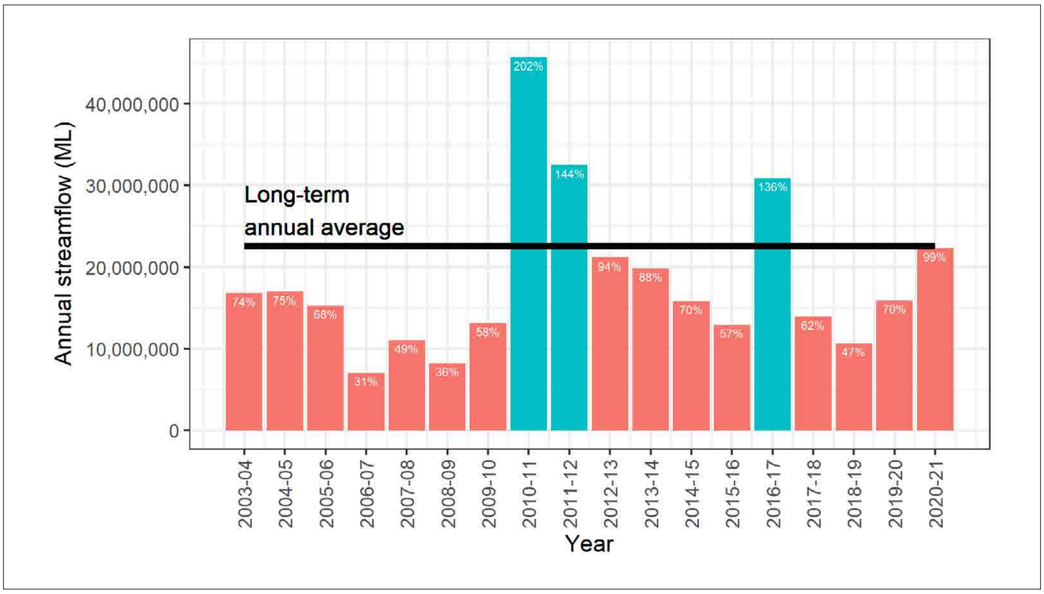


Figure WR54: Victorian streamflow compared to long-term average. Values at the top of each column represent annual streamflow as a percentage of the average Victorian long-term annual streamflow.[1915]

During the most recent five years of monitored data (2016-17 to 2020-21), 21 of 27 river basins in Victoria with measured streamflow data have been much drier than the long-term average (Figure WR55).[1916] This is a deterioration from the previous 5-year period (2011-12 to 2016-17) where 19 of 27 river basins had recorded less streamflow than the long-term average.

[1915] Department of Environment Land, Water and Planning (DELWP) 2022, 'Victorian Water Accounts 2020-2021', Melbourne, Victoria, https://www.waterregister.vic.gov.au/images/documents/Victorian-Water-Accounts-2020-2021.pdf Accessed 26 July 2022.

[1916] There are two river basins in Victoria, the Mallee and Millicent Coast basins, that have limited surface water resources and do not currently have streamflow gauges.

Inland waters — Water resources

As an average for 2016-17 to 2020-21, the Avoca basin recorded an average streamflow of less than 25% of the long-term average, while the Wimmera basin's streamflow was less than 50% of the long-term average. These two basins were also the worst performing for streamflow during the most recent year of data (2020-21), with the Avoca basin having just 4% of its long-term average streamflow during 2020-21.

During 2016-17 to 2020-21, there were four river basins that recorded higher streamflow relative to their long-term averages and an increase of streamflow compared to the previous 5-year period (compared to 2011-12 to 2015-16). Three of these river basins were in the western region (Corangamite, Glenelg and Otway Coast), and one was in the northern region (Bunyip basin).

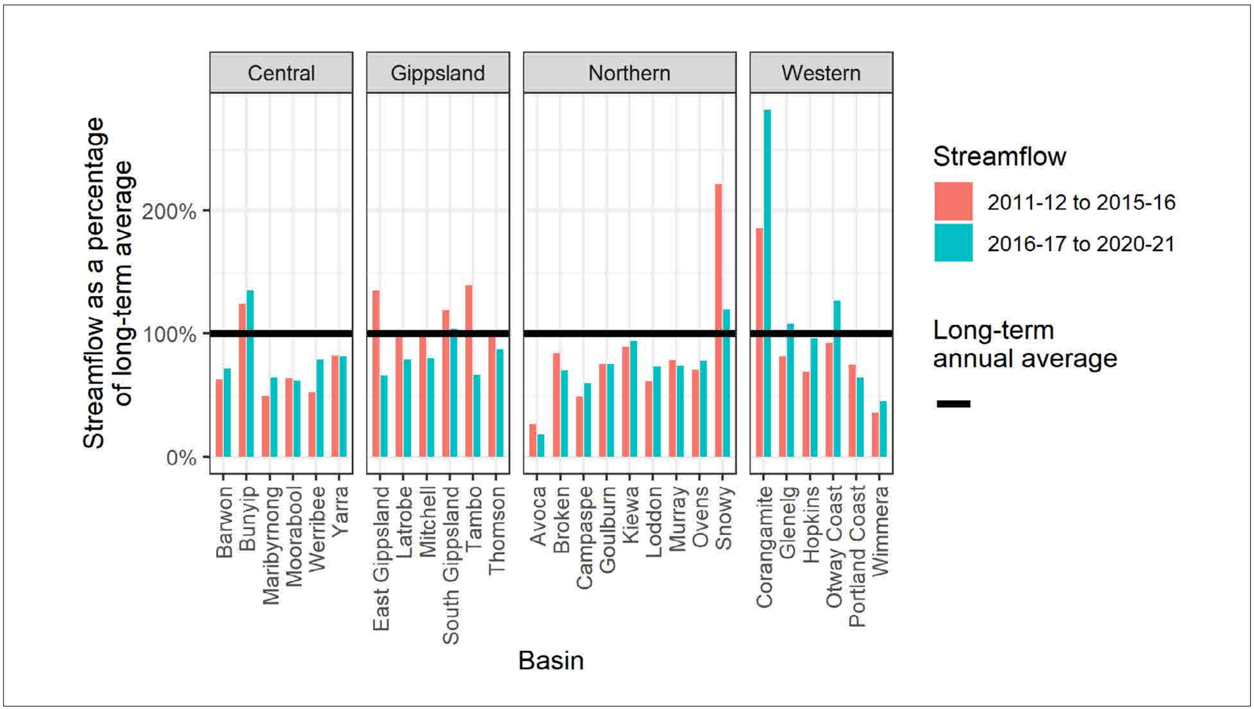


Figure WR55: Average Victorian streamflow at river basins for 2011-12 to 2015-16 and 2016-17 to 2020-21 compared to the long-term averages at each river basin. Values above 100% represent stream flows above the long-term annual average streamflow.[1917]

Figure WR56 summarises streamflow as a percentage of the long-term annual average streamflow at a regional level. During the most recent ten years of available data, streamflow as a percentage of the long-term annual average peaked in all regions in 2016-17, except for the Gippsland region that peaked in 2011-12. The Western region has exceeded the long-term average streamflow in five of the past ten years, while all the other regions have only exceeded the long-term average in two of the past ten years.

[1917] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-2021', Melbourne, Victoria, https://www.waterregister.vic.gov.au/images/documents/Victorian-Water-Accounts-2020-2021.pdf Accessed 26 July 2022.

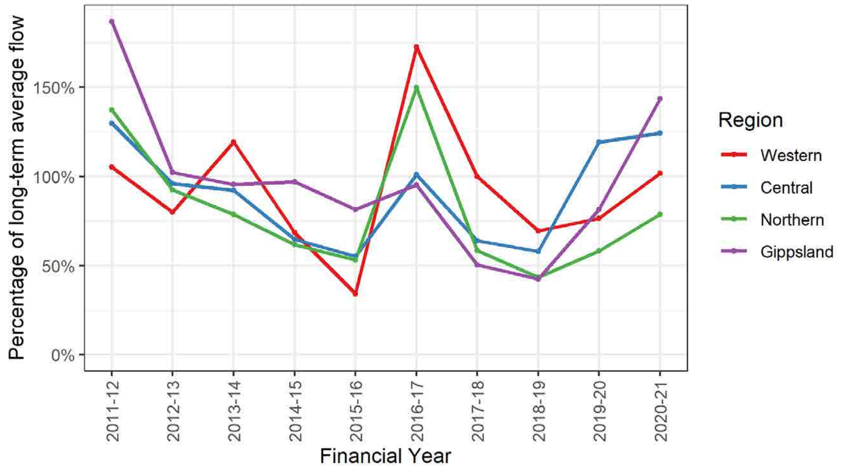


Figure WR56: Victorian financial year streamflow for each region for 2011-12 to 2020-21 compared to the long-term average.[1918]

Rainfall

Streamflow in Victoria is very strongly associated with rainfall, with a statistical analysis of streamflow and rainfall data from 2003-04 to 2020-21 showing that rainfall amounts explain 80% of the variance in Victorian streamflow from year to year. This relationship is shown in Figure WR57, which displays a scatterplot of streamflow and rainfall for each year from 2003-04 to 2020-21. The strength of the relationship between the two variables is demonstrated by the close proximity of data points to the line of best fit and high (above 0.70) R-squared value.

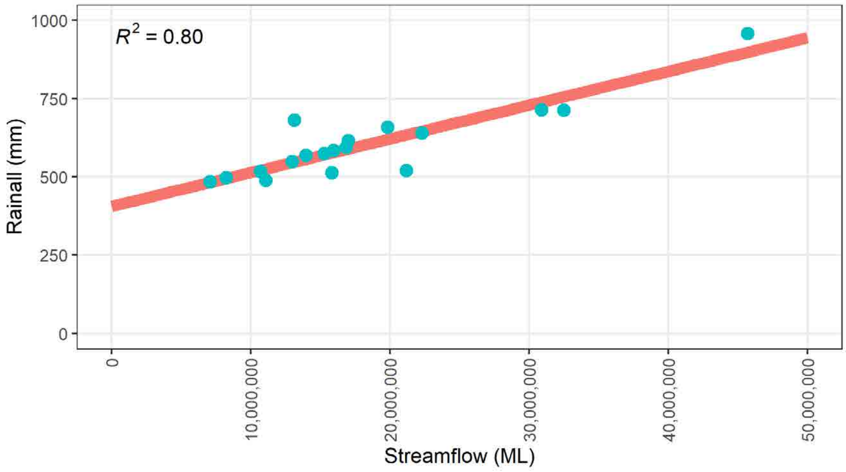


Figure WR57: Victorian streamflow and rainfall for each financial year from 2003-04 to 2020-21.[1919, 1920]

1918. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian water accounts 2020-2021', Melbourne, Victoria, https://www.waterregister.vic.gov.au/images/documents/Victorian-Water-Accounts-2020-2021.pdf Accessed 26 July 2022.
1919. Ibid.
1920. Bureau of Meteorology (BOM), 'Climate change – trends and extremes', http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=timeseries&tQ=graph%3Drranom%26area%3Dvic%26season%3D0706%26ave_yr%3D10 Accessed 25 August 2022.

With the significant effect of rainfall on streamflow established, the overarching rainfall trends can be used to understand streamflow results and project future patterns. As reported in indicator 'CC:01 Observed average rainfall', despite the year-to-year rainfall variability, there is an emerging drying trend in the state and below average rainfall has been recorded most years since the late 1990s. Above-average rainfall (relative to the period 1961-1990) has only been recorded for five years this century in Victoria (Figure WR58). Exceptions of wetter years have occurred during a 3-year period from 2009-10 to 2011-12 driven by La Niña events, during 2016-17 in association with a strong negative Indian Ocean Dipole and in 2021-22 during La Niña-influenced weather patterns. Three of the four wetter years to 2020-21 correspond with the only three years since 2003-04 that Victoria's streamflow had been greater than the long-term average — this highlights the strength of the association between rainfall and streamflow.

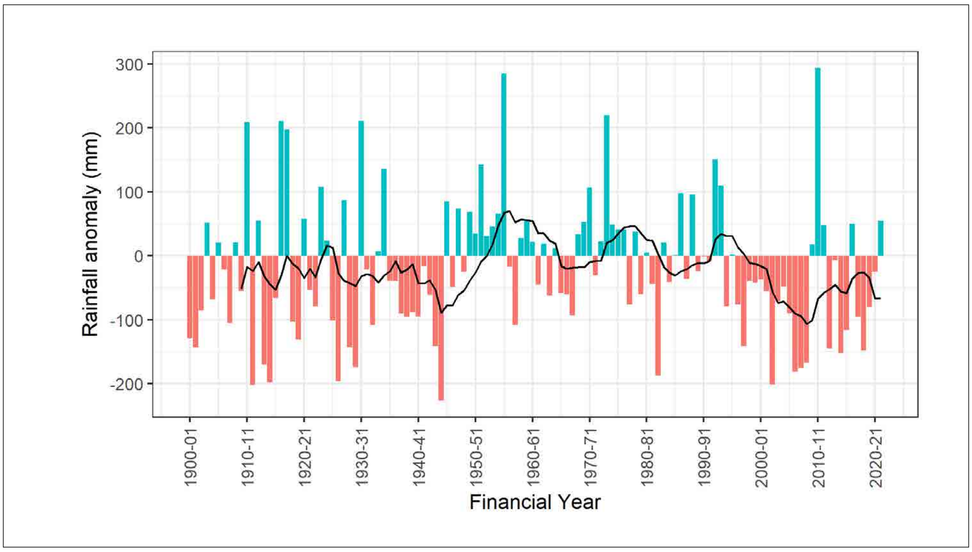


Figure WR58: Victorian financial-year rainfall anomaly, 1900-01 to 2021-22 (based on a 30-year climatology of 1961-1990 with a 10-year rolling average shown as the black line).[1921, 1922]

Despite the obvious influence of rainfall on streamflow, at a statewide scale, there are other factors that influence streamflow - and rainfall is unlikely to be responsible for the slight deterioration in streamflow from 90% of the long-term average in 2011-12 to 2015-16 to 83% in 2016-17 to 2020-21.

The most recent 5-year period (2016-17 to 2020-21) had less streamflow than the preceding 5-year period (2011-12 to 2015-16) despite having slightly more rain, with an average of 14 mm more rain per year in the more recent 5-year period (Figure WR58).

A changing relationship between streamflow and rainfall

Research conducted as part of the VicWaCI, and published in 2021, has shown that for many catchments in Victoria the runoff response to rainfall has declined, particularly during the Millennium Drought.[1923] This means that, for a given amount of rainfall, Victoria's catchments get less streamflow than in past decades. Since the Millennium Drought, some catchments have recovered while others have not; more than one-third of catchments are still in a drought-like runoff state eight years after the Millennium Drought (Figure WR59).[1924, 1925]

[1921] Bureau of Meteorology (BOM), 'Climate change – trends and extremes', http://www.bom.gov.au/climate/change/index.shtml#tabs=Tracker&tracker=timeseries&tQ=graph%3Drranom%26area%3Dvic%26season%3D0706%26ave_yr%3D10 Accessed 25 August 2022.

[1922] The average for 1961 to 1990 is 664.5 mm per year.

[1923] The Victorian Water and Climate Initiative (VicWaCI) is a partnership between DEECA, BOM, and CSIRO. The University of Melbourne was also a research partner in the first phase of VicWaCI (2017 – 2020), and Monash University provided an in-kind contribution. VicWaCI is managed by the Hydrology and Climate Science team of DEECA's Water and Catchments Group.

[1924] Department of Environment, Land, Water and Planning (DELWP), Bureau of Meteorology (BOM), Commonwealth Scientific and Research Organisation (CSIRO), University of Melbourne 2021, 'Victoria's water in a changing climate', https://www.water.vic.gov.au/__data/assets/pdf_file/0024/503718/VICWACI_VictoriasWaterInAChangingClimate_FINAL.pdf Accessed 11 April 2022.

[1925] Peterson TJ, Saft M, Peel MC, John A 2021, 'Watersheds may not recover from drought', *Science*; 372, pp. 745–749.

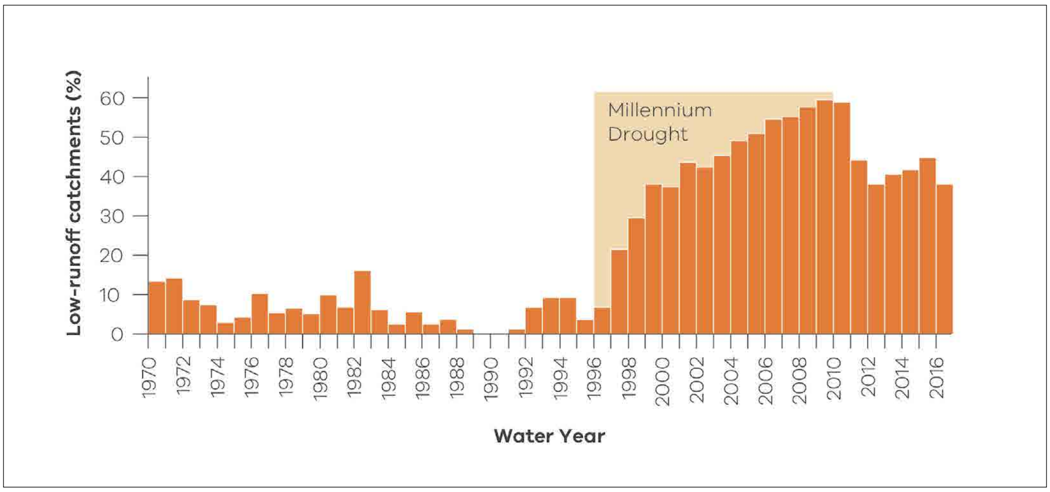


Figure WR59: Percentage of catchments generating less streamflow than expected (low-runoff state).[1926]

Coupled with the impact expected from future declines in rainfall due to climate change, the reduction in runoff response is particularly concerning for future water availability and flow-dependent ecosystems. This is likely to have significant consequences for Victoria's environment and water resources.[1927]

Water for the environment and the achievement of flow recommendations

Many of Victoria's river systems have been modified as the population has grown to provide water important for towns, industry and food production. In some rivers, up to half of the water that would have naturally flowed in them is removed each year for urban consumption, irrigation and industry. In addition, the flow timing is disrupted. Instead of flowing naturally, with high flows in winter and low flows in the hotter months of summer, rivers now run higher when water needs to be delivered for farming and urban use. These changes have interrupted many of the natural river and wetland processes needed by native plants and animals to feed, breed, and survive. Water for the environment is released into some of these rivers and wetlands to improve their health and protect environmental values.[1928, 1929]

Within indicator 'WR:09 Delivering water for the environment', complementary flow regime analysis is provided that details the percentage of flow recommendations currently being achieved in regulated Victorian rivers, and the effect of water for the environment delivery on the achievement of flow recommendations.

Projected streamflow and implications for management

Victoria's already highly variable rainfall and streamflow are now occurring against a backdrop of climate change, with the drying trend of recent decades projected to continue. An increasingly hotter and drier climate is expected to significantly reduce inflows to storages. Due to the interaction between rainfall and catchment runoff generation, streamflow is projected to decrease by a greater proportion than the percentage decrease in rainfall.

The state's water sector, including water-dependent industries and water entitlement holders, need to continue managing and planning for large variability along with increasingly hotter and drier conditions.

As competition for water resources has increased, the cumulative impacts of water harvesting have become more acute. These pressures were compounded by the conditions brought on by the Millennium Drought prior to 2010-11 that led to stream flows well below the long-term average. Diversion caps are in place and entitlements have rules that assure allocation of held water to the environment to limit the impact of extracting water for consumption.

[1926] Department of Environment, Land, Water and Planning (DELWP), Bureau of Meteorology (BOM), Commonwealth Scientific and Research Organisation (CSIRO), University of Melbourne 2021, 'Victoria's water in a changing climate', https://www.water.vic.gov.au/__data/assets/pdf_file/0024/503718/VICWACI_VictoriasWaterInAChangingClimate_FINAL.pdf Accessed 11 April 2022.

[1927] Ibid.

[1928] Victorian Environmental Water Holder (VEWH), 'What is water for the environment?', https://www.vewh.vic.gov.au/water-for-the-environment/what-is-water-for-the-environment Accessed 3 January 2023.

[1929] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian Water Accounts 2020-2021', Melbourne, Victoria, https://www.waterregister.vic.gov.au/images/documents/Victorian-Water-Accounts-2020-2021.pdf Accessed 26 July 2022.

Inland waters — Water resources

Synthesis of research on environmental outcomes from environmental watering

Victorian Environmental Flows Monitoring Assessment Program (VEFMAP)

The VEFMAP and WetMAP programs are funded by DEECA to monitor and help plan Victoria's environmental watering efforts.

VEFMAP investigates the effect that environmental flows in Victorian rivers have on native fish and aquatic and riverbank vegetation. Stage 6 of the VEFMAP program (2016-2020) has been completed, with a final report published in 2020.[1930] That report contained specific analysis towards answering 'is environmental water making a difference?' There was some broad quantitative analysis of the effect of environmental watering on fish, however, there was only a limited quantitative analysis on the impacts on vegetation due to a paucity of long-term vegetation data.

An important finding of the VEFMAP Stage 6 report was that there is overwhelming evidence that the use of environmental flow delivery is an effective management tool to enhance migration, dispersal and subsequent populations of native fish species in coastal rivers (e.g. Glenelg River) and inland rivers (e.g. Campaspe, Loddon and Goulburn rivers).

The report's analysis to determine whether environmental water was making a difference for fish provided the following insights:

- Spring river discharge and abundances of four species of juvenile diadromous (migrating between fresh and salt water) fishes were positively, with the greatest benefits of environmental water on juvenile diadromous fish immigration being achieved by providing spring flow pulses in rivers and years of low spring discharge.
- Upstream dispersal of three species of juvenile diadromous fish was enhanced in response to environmental flow releases during summer and early autumn.
- Environmental flows were a key driver of native fish immigration throughout river networks, with environmental flows playing an important role to enhance this process in flow-stressed regulated rivers.
- There is strong evidence that flows influence Murray Cod recruitment and the population dynamics of this species as well as Golden Perch, Silver Perch and Trout Cod.
- The contribution of environmental water to fish population outcomes is river-, species- and process-specific. For example, based on monitoring data and subsequent model estimates, environmental flows clearly enhanced recruitment, survival and subsequent population dynamics of Murray Cod in the Campaspe River. But those same environmental flows did not appear to enhance recruitment of Golden Perch in that system, but rather, the survival and distribution of stocked fish.

The environmental watering impact on vegetation was also assessed as part of VEFMAP Stage 6, with the following findings included in the final report:

- Environmental flows can have significant benefits to aquatic plants where they can provide essential baseflows and freshes in drier systems.
- Unlike aquatic species, emergent plant species do not require permanent water resources to survive along waterways. However, the provision of environmental flows, or natural high flow events, increase the growth and recruitment of these species.
- Fringing riparian species (e.g. grasses and herbs) are far less impacted by individual spring fresh deliveries than terrestrial species, which gives them a competitive growth advantage. This effect is cumulative, meaning that successive years of deliveries can reinforce and consolidate benefits from previous years to benefit riparian vegetation populations. Spring freshes broaden the distributions of fringing species to higher bank elevations and help to sustain healthy high-bank fringing populations by increasing fringing plant propagule dispersal and germination, and by providing temporary water resources to young or shallow-rooted species. This means that the riparian vegetation extent is much broader than it would be without environmental flows, which increases habitat resources, stabilises banks and increases overall plant community resilience to large flood events.

[1930] Tonkin Z, Jones C, Clunie P, Vivian L, Amtstaetter F, Jones M, Koster W, Mole B, O'Connor J, Brooks J, Caffrey L, Lyon J 2020, 'Victorian environmental flows monitoring and assessment program. Stage 6 Synthesis Report 2016-2020', Arthur Rylah Institute (ARI) for Environmental Research Technical Report Series No. 316. Department of Environment, Land, Water and Planning (DELWP), Heidelberg, Victoria.

Wetland Monitoring and Assessment Program for environmental water

Stage 3 of WetMAP occurred during 2017-2020 and investigated the responses of vegetation, frogs, birds and fish to environmental water. A final report for Stage 3 of WetMAP was published in 2021.[1931]

A total of 66 wetlands were surveyed, with 22 wetlands surveyed for vegetation, 30 for frogs, 25 for birds and 15 for fish. Overall, positive responses of native biota to environmental water were detected. Stage 3 represents a starting point, recognising that the responses of many biota to environmental water and water regimes are complex and influenced by longer time periods and multiple watering events.[1932]

Key findings from the WetMAP Stage 3 research included that environmental water events:

- increased both native wetland plant cover and richness, and reduced terrestrial plant cover
- increased frog species abundance and richness
- was related to the few breeding observations recorded
- increased habitat available for wetland birds and their abundance and richness
- was related to all of the breeding observations among birds
- boosted seasonal fish numbers compared to wetlands not receiving environmental water
- increased connectivity, providing opportunities for fish to move between wetland and river.[1933]

The Murray-Darling Basin Authority's Living Murray initiative

The Living Murray (TLM) initiative commenced in 2002 to improve the ecological condition of icon sites (priority environmental sites) on the Murray River in the southern Murray–Darling Basin. Report cards from 2006-07 to 2020-21 are available online for the four Victorian icon sites, with an overall grading provided as well as individual gradings for vegetation, waterbirds, fish and other taxa (e.g. frogs).[1934, 1935] The four Victorian icon sites are the major floodplain areas along the Murray River corridor: Barmah Forest, Gunbower Forest, Hattah Lakes and Lindsay, Mulcra and Wallpolla islands (Figure WR60).

Figure WR60: Location of Victorian icon sites within the Living Murray program.[1936]

[1931] Papas P, Hale R, Amtstaetter F, Clunie P, Rogers D, Brown G, Brooks J, Cornell G, Stamation K, Downe J, Vivian L, Sparrow A, Frood D, Sim L, West M, Purdey D, Bayes E, Caffrey L, Clarke-Wood B, Plenderleith L 2021, 'Wetland monitoring and assessment program for environmental water: Stage 3 Final Report', Arthur Rylah Institute (ARI) for Environmental Research Technical Report Series No. 322. Department of Environment, Land, Water and Planning (DELWP), Heidelberg, Victoria.

[1932] Department of Environment, Land, Water and Planning (DELWP), 'Assessing wetland response to water for the environment', https://www.ari.vic.gov.au/research/wetlands-and-floodplains/assessing-wetland-response-to-water-for-the-environment Accessed 29 July 2022.

[1933] Ibid.

[1934] Murray-Darling Basin Authority (MDBA) 2018, 'Icon site condition', https://apo.org.au/sites/default/files/resource-files/2018-05/apo-nid143276.pdf Accessed 27 July 2022.

[1935] Murray-Darling Basin Authority (MDBA), 'Progress and outcomes', https://www.mdba.gov.au/climate-and-river-health/water-environment/progress-and-outcomes-improving-system Accessed 29 July 2022.

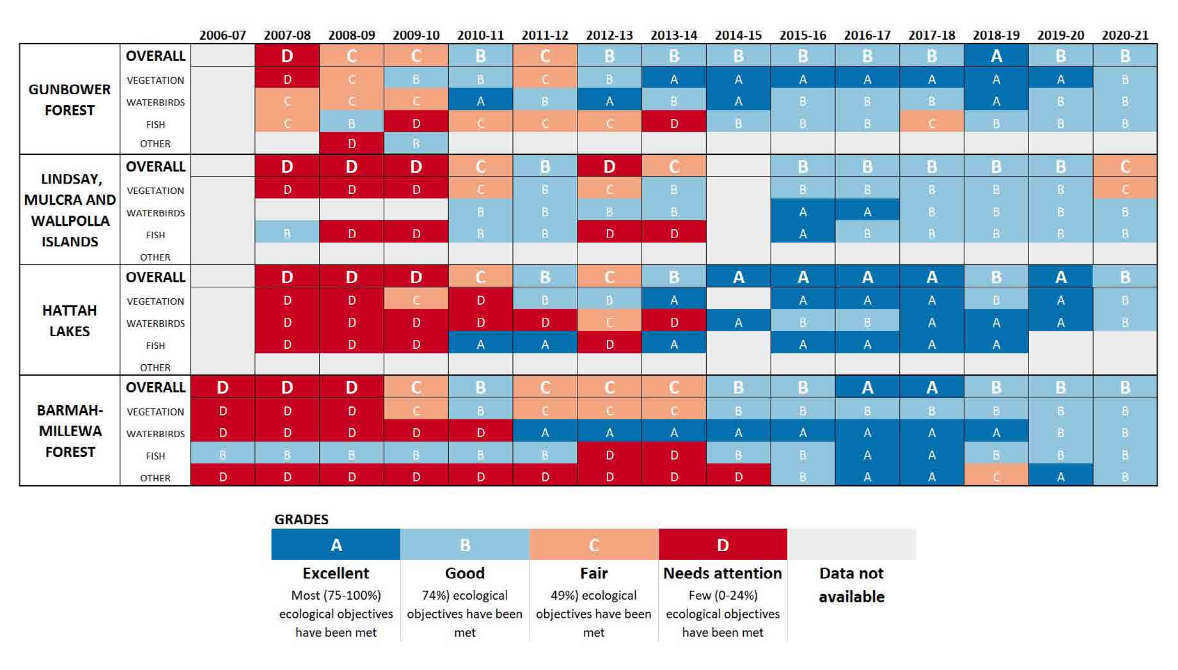
[1936] Image taken from Murray-Darling Basin Authority (MDBA) website: 'Progress and outcomes', https://www.mdba.gov.au/issues-murray-darling-basin/water-for-environment/progress-outcomes Accessed 29 July 2022.

Inland waters — Water resources

Figure WR61 shows the environmental condition report card scores for Victorian icon sites within the Living Murray program. The results of the report cards generally show an improvement in environmental condition during the 14-year period from 2006-07 to 2020-21.

The results show that the overall gradings, and gradings within sub-indices (vegetation, waterbirds, fish and other), were generally C or D for most sites from 2006-07 to 2012-13. Even though a grading of C is categorised as 'Fair' in the Living Murray program's report card system, ratings of C or D are provided when fewer than half of ecological objectives have been met and are reflective of poor environmental condition.

For the most recent 5-year period with available data (2015-16 to 2019-20), overall and sub-indices gradings at all sites were A or B, with the exception of 'fish' in Gunbower Forest in 2017-18. Similar results were found for 'other' in Barmah-Millewa Forest in 2018-19 and the 'overall' and 'vegetation' sub-indices for Lindsay, Mulcra and Wallpolla Islands in 2020-21.



		2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21
GUNBOWER FOREST	**OVERALL**		D	C	C	B	C	B	B	B	B	B	B	A	B	B
	VEGETATION		D	C	B	B	C	B	A	A	A	A	A	A	A	B
	WATERBIRDS		C	C	C	A	B	A	B	A	B	B	B	A	B	B
	FISH		C	B	D	C	C	C	D	B	B	B	C	B	B	B
	OTHER			D	B											
LINDSAY, MULCRA AND WALLPOLLA ISLANDS	**OVERALL**		D	D	D	C	B	D	C		B	B	B	B	B	C
	VEGETATION		D	D	D	C	B	C	B		B	B	B	B	B	C
	WATERBIRDS					B	B	B	B		A	A	B	B	B	B
	FISH		B	D	D	B	B	D	D		A	B	B	B	B	B
	OTHER															
HATTAH LAKES	**OVERALL**		D	D	D	C	B	C	B	A	A	A	A	B	A	B
	VEGETATION		D	D	C	D	B	B	A		A	A	A	B	A	B
	WATERBIRDS		D	D	D	D	D	C	D	A	B	B	A	A	A	B
	FISH		D	D	D	A	A	D	A		A	A	A	A		
	OTHER															
BARMAH-MILLEWA FOREST	**OVERALL**	D	D	D	C	B	C	C	C	B	B	A	A	B	B	B
	VEGETATION	D	D	D	C	B	C	C	C	B	B	B	B	B	B	B
	WATERBIRDS	D	D	D	D	D	A	A	A	A	A	A	A	A	B	B
	FISH	B	B	B	B	B	B	D	D	B	B	A	A	B	B	B
	OTHER	D	D	D	D	D	D	D	D	D	B	A	A	C	A	B

GRADES

A	B	C	D	
Excellent	**Good**	**Fair**	**Needs attention**	**Data not available**
Most (75-100%) ecological objectives have been met	74%) ecological objectives have been met	49%) ecological objectives have been met	Few (0-24%) ecological objectives have been met	

Figure WR61: Environmental condition report card scores, the Living Murray program icon sites in Victoria, 2006-07 to 2020-21.[1937, 1938, 1939, 1940]

[1937] Murray-Darling Basin Authority (MDBA), 'Barmah-Millewa Forest report card 2020-21', https://www.mdba.gov.au/climate-and-river-health/water-environment/progress-and-outcomes/barmah-millewa-forest-report-card Accessed 14 March 2023.

[1938] Murray-Darling Basin Authority (MDBA), 'Gunbower Forest report card 2020-21', https://www.mdba.gov.au/climate-and-river-health/water-environment/progress-and-outcomes/gunbower-forest-report-card-2020 Accessed 14 March 2023.

[1939] Murray-Darling Basin Authority (MDBA), Hattah Lakes report card 2020-21', https://www.mdba.gov.au/climate-and-river-health/water-environment/progress-and-outcomes/hattah-lakes-report-card-2020-21 Accessed 14 March 2023.

[1940] Murray-Darling Basin Authority (MDBA), 'Lindsay, Mulcra and Wallpolla Islands report card 2020-21', https://www.mdba.gov.au/climate-and-river-health/water-environment/progress-and-outcomes/lindsay-mulcra-and-wallpollad Accessed 14 March 2023.

Commonwealth Environmental Water Office: Long-Term Intervention Monitoring Project (2014-19) and Monitoring, Evaluation and Research Program (2019-22) for the Goulburn River

Environmental water has been delivered with the objective of enhancing native fish spawning, notably golden perch, reducing the extent of bank erosion and enhancing opportunities for establishing and maintaining water-dependant vegetation on the riverbanks, contributing to overall ecosystem carbon production, and optimising conditions for macroinvertebrate abundance.[1941]

The monitoring results have highlighted the:

- importance of winter and spring freshes, when catchments are wetter and unregulated flows may also be entering the system, for depositing sediment and seeds on riverbanks with minimal erosion, particularly if associated with a high proportion of tributary inflows
- importance of timing and magnitude of spring freshes for promoting water-dependant vegetation (early spring) and golden perch and silver perch spawning (late spring-early summer)
- contribution that Commonwealth environmental water flows make to enhancing the amount of organic carbon generated by primary production as a potential food resource for macroinvertebrates and fish when delivered any time throughout year.[1942]

Melbourne Water's water for the environment reporting as part of the Healthy Waterways Strategy 2018-28

Melbourne Water's Healthy Waterways Strategy 2018-28, published in 2018, contains 10-year catchment targets for:

- increasing the EWR volume in regulated river systems for the Maribyrnong, Werribee, Westernport and Yarra catchments.
- maintaining or improve flow regimes in unregulated river systems.
- maintaining or improving wetland water regime to support values.

Annual report cards are published online to track progress against the targets in the Healthy Waterways Strategy. The latest available report card for 'Water for the Environment' targets is from 2020-21 and highlights that progress is significantly off track in all four catchments that the target of increasing the EWR volume in regulated systems is applicable to. More detail for each catchment is provided in the dot points below:

- The Maribyrnong catchment is flow stressed, as the current water entitlements are insufficient in volume to meet all the environmental flow recommendation requirements. As there is no environmental entitlement in the Maribyrnong system, environmental watering can only occur when existing entitlement holders have available allocation that they are willing to sell. No water was available to purchase in the Maribyrnong system in 2020-21 and, therefore, no environmental watering occurred.[1943]
- The Werribee catchment is flow stressed, as the current water entitlements are insufficient in volume to meet all the environmental flow recommendation requirements. Where environmental watering was possible in this catchment in 2020-21, the attainment of environmental watering objectives was less than 60% for each type of environmental water delivery (e.g. freshes and low flows).[1944, 1945]

[1941] Treadwell S, Webb A, Hou X, Baghbanorandi P, Baker B, Bovill W, Casanelia S, Christopher N, Grace M, Greet J, Kellar C, Koster W, Lovell D, McMahon D, Morris K, Pettigrove V, Russell L, Sutton N, Vietz G 2021, 'Commonwealth Environmental Water Office monitoring, evaluation and research program: Goulburn River selected area summary report 2020–21', University of Melbourne, Victoria.

[1942] Ibid.

[1943] Healthy Waterways Strategy, 'Maribyrnong catchment - Progress towards performance objectives in rivers', https://healthywaterways.com.au/report-card?suId=MAR&tabId=river& Accessed 29 July 2022.

[1944] Low flows provide a continuous stable, sustained low level flow in a river. The flow may be limited to a narrow area of the river channel but is important as it connects habitats within the channel and supports plants and animals that only live in water. Low flows also keep the riverbed and lower banks wet helping to maintain native plants and trees that live beside waterways.

[1945] Healthy Waterways Strategy, 'Werribee catchment - Progress towards performance objectives in rivers', https://healthywaterways.com.au/report-card?suId=WER&tabId=river& Accessed 29 July 2022.

Inland waters — Water resources

- The Tarago River system in the Westernport catchment is flow stressed, as the current water entitlements are insufficient in volume to meet all the environmental flow recommendation requirements. Passing flows released from Candowie Reservoir provided freshening flows for Tennant Creek in the Bass River sub-catchment. Where environmental watering was possible in the Westernport catchment in 2020-21, the attainment of environmental watering objectives was generally greater than 80%.[1946]
- The Yarra catchment is flow stressed as the current water entitlements are insufficient in volume to meet all the environmental flow recommendation requirements. Where environmental watering was possible in the Yarra catchment in 2020-21, the attainment of environmental watering objectives fluctuated from 100% for summer/autumn and winter/spring freshes and spring high flows to 50% or less for summer/autumn low flow and autumn high flow.[1947, 1948]
- Unregulated systems do not have large water storages such as dams or reservoirs. They are managed through licenced private diversions and may include local management plans in high priority water supply protection areas. These management plans include environmental water action plans (EWAPs) which are joint management plans developed with various stakeholders (e.g. Melbourne Water, local government, Southern Rural Water and Parks Victoria) for the management of environmental water in a particular area. In 2020-21, the EWAP programs delivered by Melbourne Water in its catchments were reviewed and a refined program is in development.[1949]

[1946] Healthy Waterways Strategy, 'Westernport catchment - Progress towards performance objectives in rivers', https://healthywaterways.com.au/report-card?suId=WES&tabId=river& Accessed 29 July 2022.

[1947] High flows are larger and last longer than freshes. They usually fill at least half the river channel, and therefore are important for plants that grow higher up the bank. High flows also encourage some species of fish to move and breed.

[1948] Healthy Waterways Strategy, 'Yarra catchment - Progress towards performance objectives in rivers', https://healthywaterways.com.au/report-card?suId=YAR&tabId=river& Accessed 29 July 2022.

[1949] Healthy Waterways Strategy, 'Port Phillip and Westernport region - Progress towards 10-year catchment targets', https://healthywaterways.com.au/report-card?suId=PPW&tabId=river& Accessed 29 July 2022.

Inland waters — Water resources

Indicator WR:09 Delivering water for the environment

WR:09 Delivering water for the environment						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🟡	→	🟡	🟡	→	🟢
Data source(s):	VEWH					
Measure(s):	Achievement of required potential watering actions Percentage of flow recommendations fully, partially or not achieved for rivers and wetlands, with and without the contribution of water for the environment					

Why this indicator?

Environmental water is critical for the protection of plants and animals, and for the overall health of rivers, wetlands, floodplains and estuaries. It also has social, cultural and economic benefits.

This indicator is designed to assess how much water is being delivered under environmental entitlements and how that delivery is helping to achieve the scientifically recommended water regime.

NB: This SoE 2023 indicator was 'WR:04 Delivering water for the environment' in the SoE 2018 Report.

Why this assessment in 2023?

The VEWH fully achieves most of its planned annual watering actions. However, despite this level of achievement, there remains a significant shortfall to fully achieve the scientifically recommended flow regimes. This highlights a significant gap between what Victorian river systems need from a hydrological perspective and what the VEWH can currently achieve from its environmental watering program.

The results show that water for the environment is having a greater impact on fully achieving wetland watering requirements than it is on fully achieving optimum river flows. However, these results include assessments for only those rivers and wetlands where environmental water is being delivered, which incorporates most of the regulated rivers in Victoria but only a small percentage of regulated wetlands.

Based on water for the environment being shown to contribute to the achievement of flow recommendations in all regions, but river systems still generally not fully achieving the scientifically recommended flow regimes, the status of this indicator has been assessed as fair. The confidence is rated as moderate because the contribution of water for the environment to achieving each of the intended hydrological outcomes is variable. Further research is underway to quantify this and will be included in the indicator assessment in the SoE 2028 Report.

Summary of State of the Environment 2018 Report assessment

- For each year from 2011-12 to 2017-18, 55% to 70% of the environmental entitlement was delivered.
- Nearly twice as much water was delivered in 2017-18 compared with 2011-12.

Critical data used for the 2023 assessment

- VEWH Annual Report 2020-21 for delivery and carryover of water for the environment allocated under environmental entitlements and percentage of the VEWH's planned potential watering actions that have been fully or partially achieved annually
- VEWH data on percentage of flow recommendations fully or partially achieved in river systems and wetlands receiving environmental entitlement

Inland waters — Water resources

2023 assessment

Availability and delivery of water for the environment

Water entitlements, allocations and carryover are important elements of environmental water management. An environmental water entitlement is a legal right to a share of water that is managed to benefit the environment at a location (environmental water entitlements are held in 15 water supply systems across Victoria). A water 'entitlement' defines the maximum amount of water that can be allocated each year. A water 'allocation' is the amount of water given to an entitlement holder each year by the relevant resource manager. Some entitlements allow the VEWH to carry over unused water to the following water year. This means that water allocated in one year can be kept in storages for use in the following year, subject to certain conditions. For example, in a wet season an entitlement holder would usually be allocated 100% of their entitlement, but in a dry season they might get less. To mitigate against water supply shortfalls, entitlement holders don't always use all their water allocations. This is called 'carryover' and is a strategy to save water for subsequent dry years and to provide more flexibility to deliver water when it is of the greatest value to the environment. Carryover can also be used to help environmental water holders to meet high winter and spring demands when there is a risk there will be little water available under entitlements at the beginning of the water year. There are rules in place to make sure that carryover water doesn't unfairly impact on other entitlement holders' allocations.

The delivery and carryover of water for the environment for Victoria since 2011-12 is provided in Figure WR62. The overwhelming majority (84%) of water delivered during this period occurred in the northern region river systems.

The volume of water for the environment that has been delivered each year has remained above 500,000 ML in each of the past five years (2016-17 to 2020-21), with an average delivery of 743,402 ML per year. This is up 21% from the volume of water delivered in the previous 5-year period (2011-12 to 2015-16). Likewise, the amount of carryover water has also increased during the past five years; up by 24% as at 2020-21 compared to the carryover at 2015-16. This demonstrates that more water has been available and delivered for the environment during this state of the environment reporting period.

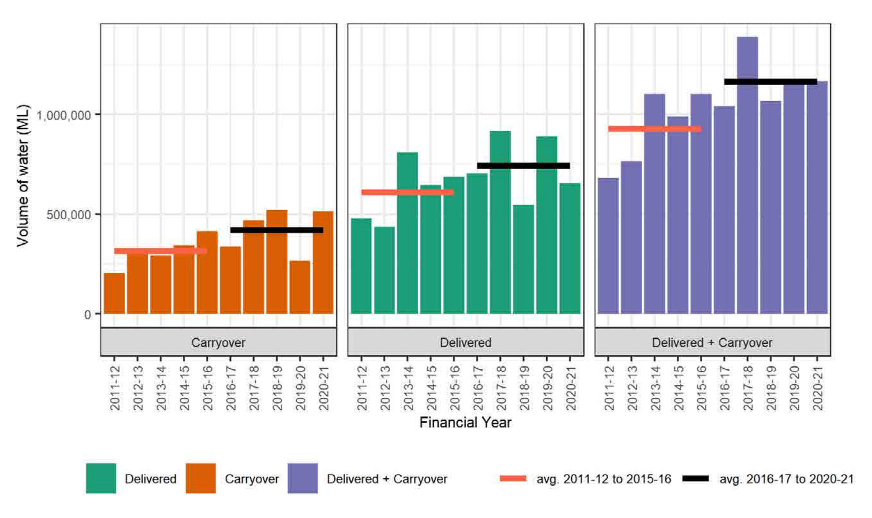


Figure WR62: Delivery and carryover of water for the environment, allocated under environmental entitlements for 2011-12 to 2020-21.[1950]

[1950] Victorian Environmental Water Holder (VEWH) 2021, 'Annual report 2020-21', Melbourne, Victoria, https://www.vewh.vic.gov.au/__data/assets/pdf_file/0006/544461/VEWH-Annual-Report-2020-21.pdf Accessed 24 June 2022.

Inland waters — Water resources

As discussed earlier, water allocations are generally greater in wet years compared to dry years. Therefore, a 21% increase in water for the environment delivery occurred this five-yearly state of the environment reporting period (an increase for 2016-17 to 2020-21 relative to 2011-12 to 2015-16), and a 24% increase in carryover, represents a likely relative improvement in water availability for the environment given Victoria's total rainfall for the same period only increased by 2.5%. It is important to note that this analysis of delivery and carryover of water for the environment is best interpreted as an indicative guide to water availability for the environment because, even though it has been averaged across a five-yearly period, environmental water allocations, delivery and carryover do fluctuate from year to year.

A robust assessment of environmental water allocations over a longer period was completed for southern Victorian river systems in 2020 as part of the LTWRA for Southern Victoria. That assessment found that long-term surface water availability across southern Victoria has declined by up to 21%. The assessment determined that the decline in water availability has not always been shared equally, with the declines falling disproportionately on the environment in some basins. The assessment also found that a smaller share of available water is now set aside for the environment than when the last sustainable water strategies were developed between 2006 and 2011. The results of the Long-Term Water Resources Assessment for Southern Victoria were used to inform the Central and Gippsland Region Sustainable Water Strategy that was published in 2022, and which sets actions that are required to increase the volume of environmental water in several basins (e.g. Barwon, Moorabool, Werribee, Maribyrnong, Yarra, Thomson and Latrobe basins). A LTWRA for northern Victoria is scheduled to commence in 2025 to align with the Murray-Darling Basin Plan review scheduled for 2026.

Hydrological outcomes

Only tracking the overall delivery of water for the environment is not enough to determine the impact and effectiveness of environmental watering.

The volume, timing, duration, frequency and quality of the environmental flows that are provided can also be important. Different combinations of these variables provide a range of ecosystem benefits. For example:

- Releasing small amounts of water, called 'freshes', through summer helps to maintain or improve water quality and can trigger life-history processes for aquatic biota (e.g. spawning and migration).
- Sustained high flow in spring can replenish a river channel by providing soil and nutrients for floodplains, as well as being vital for waterbirds and native fish to breed.[1951] However, the success of these activities is dependent on the flows connecting the floodplain, and this is often not possible due to the risk of inundating private land.
- Maintaining baseflows over summer provides a continuous, stable, and sustained low-level flow in a river to connect habitats within the channel and support plants and animals that only live in water. This also helps keep the riverbed and lower banks wet, which in turn, helps maintain native plants and trees that live along waterways.[1952]

In addition to the seasonal nuances, watering requirements can vary considerably between wet and dry years. In drought and dry conditions, the aim is to prevent catastrophic losses and maintain critical refuge habitats to prevent significant declines in native species populations. In wet conditions, the aim shifts to boosting ecological productivity and environmental condition and to increasing populations of native plants and animals.[1953]

Each year, as required under the Victorian Water Act, the VEWH publishes a seasonal watering plan detailing the potential watering actions that may be delivered to each system. The potential watering actions are developed by regional waterway managers, with support from the VEWH, and are based on environmental flow studies and longer-term plans (e.g. environmental water management plans, technical environmental flow studies, regional waterway strategies, Ramsar site management plans and regional catchment strategies).[1954]

[1951] Victorian Environmental Water Holder (VEWH), 'What is water for the environment?', https://www.vewh.vic.gov.au/water-for-the-environment/what-is-water-for-the-environment Accessed 3 January 2023.

[1952] Victorian Environmental Water Holder (VEWH), 'Understanding flows, some terminology explained', https://www.vewh.vic.gov.au/news-and-publications/stories/understanding-flows-some-terminology-explained Accessed 24 January 2023.

[1953] Victorian Environmental Water Holder (VEWH) 2021, 'Seasonal watering plan 2021–22', Melbourne, Victoria, https://www.vewh.vic.gov.au/__data/assets/pdf_file/0005/542516/26865-VEWH-SWP-Complete-LR-WEB.pdf Accessed 24 June 2022.

[1954] Considerable science and community knowledge exists about the water needs of plants and animals in rivers and wetlands. Using this knowledge, specific studies have identified the types of flows a particular river needs — or the wetting and drying patterns needed by a wetland. Flow studies provide information about the timing, watering duration and amount of water needed by native plants and animals. Many flow studies have been developed for rivers and wetlands that receive water for the environment.

The seasonal watering proposals incorporate information and advice from local communities, including Traditional Owners and other land managers.[1955]

In 2019-20, the VEWH refined its method for assessing achievement of potential watering actions. The method uses direct measures of streamflow, including gauged readings and debited environmental water use to determine the extent to which the required magnitude, duration, timing and frequency of each required watering action is met. These results are all combined to produce an achievement score of achieved, partially achieved or not achieved for each the actions.[1956]

For this SoE 2023 Report, the VEWH has supplied data that uses the methodology outlined above to assess the full set of flow recommendations that are included within individual technical reports for rivers and wetlands that receive water for the environment. To prepare the data, the VEWH used hydrological data to assess achievement of potential watering actions.

The extent to which flow recommendations are currently being achieved is a good starting point to understand both the need for, and the effect of, water for the environment, noting that the objective for environmental watering is not necessarily to achieve flow study recommendations. This is detailed further within indicator 'WR:08 Condition of flow regimes', however, a key finding from river flow data is repeated here. The finding is that for each of the five years from 2017-18 to 2021-22, an analysis of river flow data determined that between 19% to 35% of flow study recommendations were fully achieved across Victoria. A further 43% to 51% of flow study recommendations were partially achieved each year, with 22% to 33% of recommendations not achieved. The results also show slightly higher levels of fully achieved flow recommendations in the most recent two years (2020-21 and 2021-22) that experienced increased rainfall associated with La Nina events.

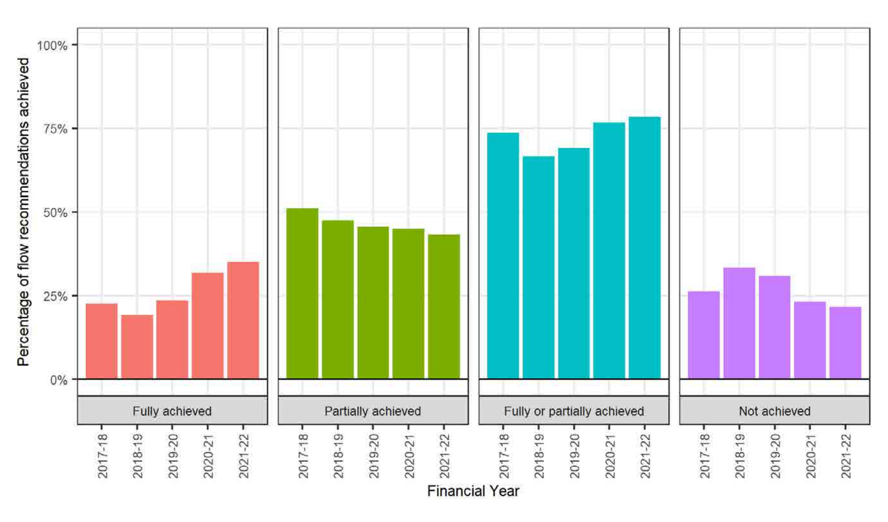


Figure WR63: Percentage of flow recommendations achieved in river systems that receive environmental entitlements from 2017-18 to 2021-22.[1957]

1955. Victorian Environmental Water Holder (VEWH) 2021, 'Seasonal watering plan 2021–22', Melbourne, Victoria, https://www.vewh.vic.gov.au/__data/assets/pdf_file/0005/542516/26865-VEWH-SWP-Complete-LR-WEB.pdf Accessed 24 June 2022.
1956. Victorian Environmental Water Holder (VEWH) 2021, 'Annual report 2020-21', Melbourne, Victoria, https://www.vewh.vic.gov.au/__data/assets/pdf_file/0006/544461/VEWH-Annual-Report-2020-21.pdf Accessed 24 June 2022.
1957. Victorian Environmental Water Holder (VEWH), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

The results in Figure WR63 provide an overview of the current state of flow regimes in Victoria and show that the scientifically recommended flow regimes are generally not being fully achieved across the state. However, it is important to note that partially achieved recommendations can still be indicative of good outcomes, and a large proportion (between 43-51% each year) of flow recommendations are being partially achieved. In addition to the 19% to 35% of flow recommendations being fully achieved, the level of partial achievement means that there is progress towards achieving approximately 75% of flow recommendations each year. The results vary from region to region and river system to river system, with the Gippsland region having the highest percentage of fully achieved flow recommendations for rivers, while the Western region has the lowest percentage. This is most likely due to the Gippsland region receiving more rainfall.

It is clear there is a large shortfall on what many river systems need to achieve optimal flow regimes. This is significant when considered alongside Figure WR64 that presents data from the VEWHs annual reporting and shows between 63% to 70% of its planned potential watering actions have been fully achieved (and 87-92% have been fully or partially achieved) for each of the past three years (2019-20 to 2021-22).

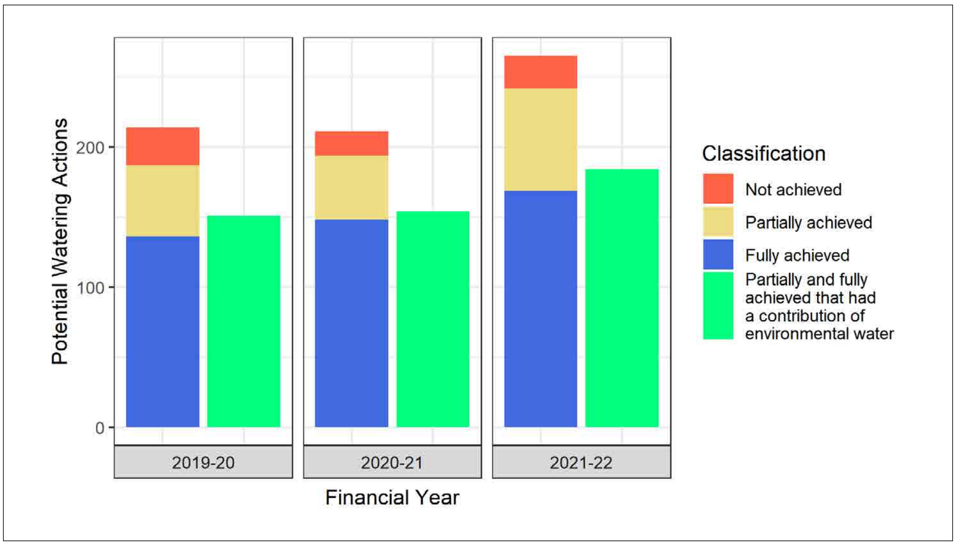


Figure WR64: Achievement of required potential watering actions from 2019-20 to 2021-22.[1958]

Figure WR64 shows that the VEWH is generally having success fully achieving what it has planned to achieve in terms of its potential watering actions each year. However, despite this level of achievement, there remains a large shortfall to fully achieve the scientifically recommended flow regimes. This highlights a significant gap between what the river systems need from a hydrological perspective and what the VEWH can currently achieve from its environmental watering program.

Contribution of water for the environment to delivering the scientifically recommended flow regime

In addition to the previous analysis on the percentage achievement of the scientifically recommended flow regime in river systems for 2017-18 to 2021-22 (Figure WR63), analysis provided by the VEWH for this report estimates the contribution of water for the environment towards achieving flow recommendations in river systems and wetlands. This analysis is provided for the most recent two years (2020-21 and 2021-22) when the more detailed data were available.

[1958] Victorian Environmental Water Holder (VEWH) 2021, 'Annual report 2020-21', Melbourne, Victoria, https://www.vewh.vic.gov.au/__data/assets/pdf_file/0006/544461/VEWH-Annual-Report-2020-21.pdf Accessed 24 June 2022.

The results show that water for the environment is having a much greater impact on fully achieving wetland watering requirements than it is on fully achieving optimum river flows. These results include assessments only for rivers and wetlands where environmental water is being delivered, which incorporates most of the regulated rivers in Victoria but only a small percentage of regulated wetlands. It is likely that better achievement of recommended water regimes is occurring at wetlands because environmental watering of wetlands targets many of Victoria's highest value wetlands in dedicated locations. In some instances, dedicated environmental infrastructure (e.g. pumps) is deployed to enable delivery of environmental water entitlements to priority and icon sites. In contrast, environmental watering of river systems is more heavily impacted by available volumes of held environmental entitlements, the natural seasonal conditions in any given water year, physical constraints within delivery systems (e.g. outlet valve capacities) and policy constraints (e.g. the obligation to avoid deliberately flooding towns and private land).

These points explain why a lower percentage of flow recommendations are being fully achieved for river systems. However, it is important to note that the delivery of water for the environment is leading to at least partial achievement of most flow recommendations, and partially achieved actions still deliver good outcomes.

Averaged across 2020-21 and 2021-22, wetlands would not have achieved 79% of their watering requirement and would have only fully achieved 14% without the delivery of water for the environment (the remaining 7% of requirements would have been partially achieved). However, the water that was delivered resulted in 91% of wetland watering requirements being fully achieved during those two years, with only 7% of requirements not being achieved (the remaining 2% of requirements were partially achieved). This analysis, displayed in Figure WR65, clearly demonstrates that, where water for the environment is being delivered to wetlands, the water regime requirements of those wetlands are largely being achieved.

The impacts of water for the environment are not as profound for river systems relative to the impacts on wetlands (Figure WR65). Averaged across 2020-21 and 2021-22, without the delivery of water for the environment, river systems would not have achieved 30% of their flow recommendations and would have only fully achieved 19% (the remaining 51% of flow recommendations would have been partially achieved). The water that was delivered only resulted in a slight increase to 33% of river system flow recommendations being fully achieved during those two years, and a slight decrease to 22% in the number of recommendations that were not achieved (the remaining 44% of recommendations were partially achieved).

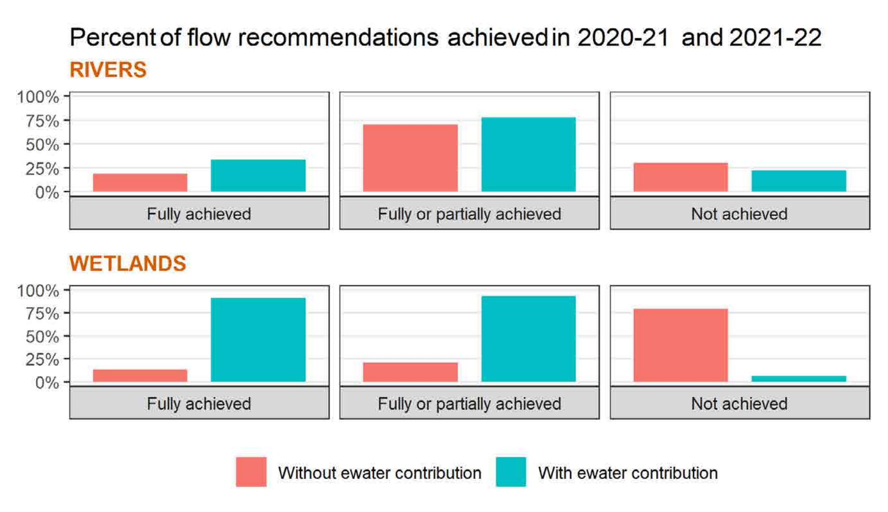


Figure WR65: Percentage of flow recommendations achieved for rivers and wetlands without an environmental water contribution (red) and with an environmental water contribution (blue) for 2020-21 and 2021-22.[1959]

[1959] Victorian Environmental Water Holder (VEWH), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

Figure WR66 displays a regional breakdown of the flow recommendations that were fully achieved in 2020-21 and 2021-22, with further categorisations provided by the type of system (rivers or wetlands) and whether there was a contribution from environmental water delivery. The graphs show a reasonably consistent pattern across all regions, albeit with the Gippsland region having the highest percentage of fully achieved flow recommendations for rivers, while the Western region having the lowest percentage. As discussed previously, this is most likely due to Gippsland region receiving more rainfall.

The key information in Figure WR66 is that water for the environment contributed to a limited improvement in the number of flow recommendations fully achieved in river systems across all regions, and a substantial improvement for the wetlands that have been targeted for watering. Note that partially achieved actions still deliver good outcomes, and partially achieved actions are incorporated in Figure WR65 that shows a significant amount of partially achieved flow recommendations for Victorian river systems.

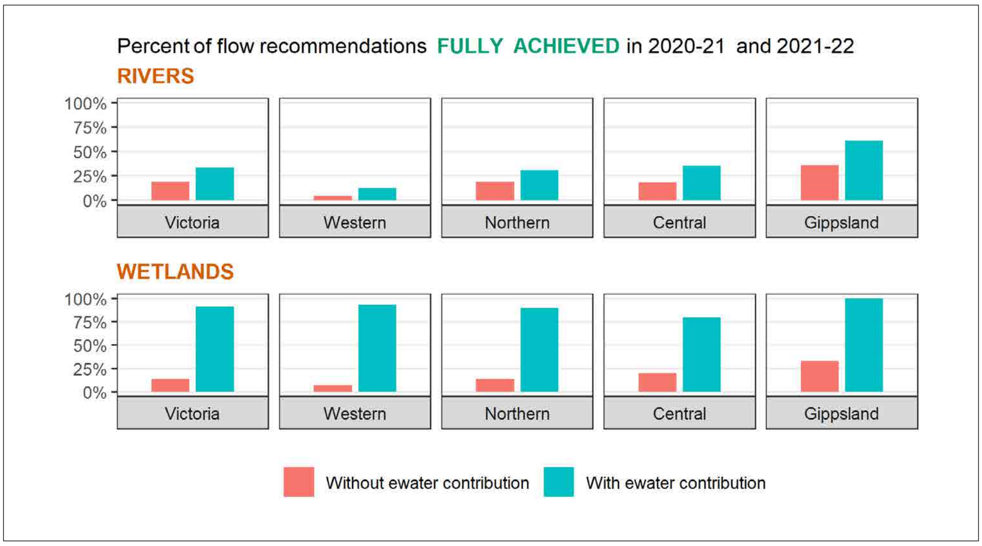


Figure WR66: Percent of flow recommendations fully achieved in Victorian rivers (top) and wetlands (bottom), averaged for 2020-21 and 2021-22.[1960]

The exact contribution of water for the environment to achieving each of the intended hydrological outcomes is variable. For example, for some of the hydrological outcomes, water for the environment will be the primary reason the outcomes were met, while for others the delivery of water for the environment will have only been a minor contributor and climatic influences or water extractions will have been more influential. DEECA has commenced work to quantify the relative contribution of water for the environment to achieving hydrological outcomes and it is expected that this work will inform future assessments for this indicator.

The results presented in Figure WR66 show that water for the environment is having a much greater positive effect on hydrology at selected wetlands, relative to river systems. Further research is required to determine the likely effect of additional water delivery on river system flows — in other words, if extra water was delivered for the environment, would that make much of an impact of fully achieving flow recommendations? A detailed analysis of the types of flow components that have higher rates of non-achievement would help target future policy development and delivery of water for the environment to the flow types and locations where flow recommendations are not being achieved.

[1960] Victorian Environmental Water Holder (VEWH), 'Unpublished data', Melbourne, Victoria, Accessed 2022.

An initial assessment of the flow recommendation data provided by the VEWH shows freshes are the most frequent type of watering action and the action with the highest rate of fully achieving flow recommendations during 2020-21 and 2021-22 (with greater than 40% of freshes leading to fully achieved flow recommendations).[1961, 1962] The greatest rates of non-achievement occurred for overbank and bankfull flows, with those flows not being able to achieve more than 50% of flow recommendations.[1963, 1964, 1965, 1966] This analysis indicates that higher flows are usually the types of watering actions that aren't achieving flow recommendations. The reasons for this are likely to be a combination of higher flows requiring a large volume of entitlement as well as the physical and policy constraints discussed previously in this indicator narrative (e.g. outlet valve capacities and the need to avoid flooding private land).

Synthesis of research on community outcomes from environmental watering

Quantifying the social and economic benefits from environmental watering is an increasing area of focus, with several Victorian studies completed in recent years. The greater recognition of these themes has occurred in conjunction with amendments to the Water Act that, as of October 2019, which states that one of the functions of Water Holders and Water Corporations is that they must consider opportunities to provide for Aboriginal cultural values and uses of waterways as well as the social and recreational uses and values of waterways.[1967]

Socio-economic outcomes of environmental watering in northern Victoria

Healthy rivers, floodplains and wetlands in northern Victorian catchment areas provide a range of benefits that are important for society and the economic system both within these areas and across Victoria. To help understand the nature and extent of these socio-economic benefits, the VEWH, in collaboration with the Mallee CMA, North Central CMA, Goulburn-Broken CMA and DELWP, engaged Natural Capital Economics to describe and evaluate these benefits in economic terms. This work was published in 2020.[1968]

By looking at case studies of just a few benefits at a limited number of key sites, the Natural Capital Economics report shows water for the environment is estimated to contribute between $30 to $79 million a year to northern Victorian communities — a figure that is forecast to more than double over the next decade to an estimated $68 to $168 million annual contribution.[1969]

A key insight of the analysis was that environmental watering provides substantial benefits to segments of the agriculture sector. One important benefit is the contribution of healthy *eucalypt* forests (particularly river red gum forests) in supporting commercial pollination services to almond production. These benefits are estimated to be in the range of $13 million to $38 million per year, and largely accrue to the Mallee region where almond production in Victoria is located.[1970]

[1961] Freshes are short-duration flow events that submerge the lower parts of the river channel. They are important for plants that grow low on the banks and provide opportunities for fish and other animals to move more easily along the river.

[1962] Victorian Environmental Water Holder (VEWH), 'Understanding flows, some terminology explained', https://www.vewh.vic.gov.au/news-and-publications/stories/understanding-flows-some-terminology-explained Accessed 24 January 2023.

[1963] Overbank flows exceed channel capacity and spill onto the floodplain. These flows improve floodplain productivity, fill wetlands that provide feeding and breeding opportunities for waterbirds, fish, frogs and turtles, allow animals to move between the river channel and floodplain and help disperse plant seeds and fragments, nutrients and carbon.

[1964] Victorian Environmental Water Holder (VEWH), 'Understanding flows, some terminology explained', https://www.vewh.vic.gov.au/news-and-publications/stories/understanding-flows-some-terminology-explained Accessed 24 January 2023.

[1965] Bankfull flows are large enough to fill the river channel with little spill onto the floodplain. Bankfull flows have high energy and they move large amounts of sediment and help to shape the river channel. They can also act as a trigger for breeding in some fish species.

[1966] Victorian Environmental Water Holder (VEWH), 'Understanding flows, some terminology explained', https://www.vewh.vic.gov.au/news-and-publications/stories/understanding-flows-some-terminology-explained Accessed 24 January 2023.

[1967] State Government of Victoria, 'Water Act 1989', Authorised Version No. 138, https://content.legislation.vic.gov.au/sites/default/files/2022-08/89-80aa138%20authorised.pdf Accessed 14 March 2023.

[1968] Natural Capital Economics 2020, 'Socio-economic outcomes of environmental watering in northern Victoria', Final Report, 4 March 2020.

[1969] Ibid.

[1970] Ibid.

Inland waters — Water resources

Social and economic impacts of the Murray-Darling Basin Plan in Victoria

The Victorian Government commissioned an independent social and economic analysis to understand how irrigators and communities across the southern connected basin have been impacted by the Murray Darling Basin Plan. The report was published in 2017.[1971]

Rather than quantifying social and economic benefits (or disadvantages), the report instead provided analysis on various agricultural sectors and their activities and allocations within the water market, and found:

- The dairy industry in Victoria is now more exposed to the water market and heavily reliant on the allocation market. The dairy sector will be the first group to be exposed to the risk of rising allocation prices.
- The horticulture sector in Victoria has purchased large amounts of Victorian High Reliability Water Shares, now claiming more than 40%. If allocations drop below 40%, there will not be enough water to supply industries across Victoria, New South Wales and South Australia.
- Victorian High Reliability Water Shares have been disproportionately targeted by the Commonwealth in the past. This has increased Victoria's risk in dry years, as the entitlement market helps to lessen the impact of drought in Victoria.
- Reduced water availability may impact future tariffs and system infrastructure requirements.
- Irrigators who previously participated in Commonwealth buybacks are now much more reliant on allocation purchases; from 0% to 12% on the allocation market prior to participation to 26% to 52% after participation.[1972]

The economic and social contribution of selected waterways and waterbodies in the North East CMA to the regional economy

A study assessing the economic and social contribution of selected waterways and waterbodies in the North East CMA to the regional economy was completed by Street Ryan and Associates Pty Ltd on behalf of the North East CMA.[1973] The study involved interviewing more than 2,000 people between 2017 and 2019 that use and visit the waterways and waterbodies, local businesses and service providers.

The report estimated that, on an annual basis:

- $28.6 million is contributed to the North East CMA region in north-east Victoria from the 19 selected recreational waterways and waterbodies in the study. This contribution includes expenditure by overnight visitors, active day visitors (e.g. swimmers, anglers, canoers) and passive day visitors (e.g. walkers, runners, picnickers).
- $2.5 million of annual benefits were calculated for health outcomes from participation at waterways and waterbodies. These benefits include chronic diseases that are prevented by active lifestyles as well as mental health benefits derived from the prevention of anxiety and depression.[1974]

1971. TC&A, Frontier Economics Pty Ltd 2017, 'Social and economic impacts of the basin plan in Victoria', https://www.water.vic.gov.au/__data/assets/pdf_file/0021/600717/Social-and-Economic-impacts-of-Basin-Plan-water-recovery-in-Victoria.pdf Accessed 29 July 2022.
1972. Department of Environment, Land, Water and Planning (DELWP), 'Social and economic impacts of the basin plan in Victoria', https://www.water.vic.gov.au/mdb/mdbp/social-and-economic-impacts-of-the-basin-plan-in-victoria Accessed 29 July 2022.
1973. North East Catchment Management Authority (CMA) 2019, 'North East region socio-economic value of recreational water: Selected waterways and waterbodies', Wodonga, Victoria, https://www.necma.vic.gov.au/Portals/0/NECMA_SHARED%20BENEFITS_SINGLE%20PAGES.pdf Accessed 29 July 2022.
1974. Ibid.

Inland waters — Water resources

River flows and their social and economic value for the Barwon and Moorabool Rivers in Geelong

Based on the predicted frequency of low river levels and algal events including the benefits of water recovery scenarios, the Barwon and Moorabool rivers currently provide an annual value of approximately $19.9 million to the Geelong community.[1975] Adopting an optimal water recovery scenario (which approximates to the minimum 5,140 ML/year water recovery target from Lal Lal Reservoir and 3,773 ML/year water recovery target from West Barwon Reservoir) is estimated to add $3.8 million to the annual value, while being able to avoid low water levels and algal blooms would annually add $4.8 million of value.[1976]

The benefits are largely driven by land use surrounding the river, for example, recreation, aesthetic and social events, as well as the willingness to pay a premium for housing near the river. On an annual basis, the river and surrounding areas are visited approximately 500,000 times for recreation.

Over a 40-year period, the benefit of an optimal flow scenario is estimated to be a net present value of $95 million, assuming the continuation of the current climate and consumptive demands.

Recreational fishing

Recreational fishing and boating are popular activities in Victoria.

Twenty-eight of the top 50 Victorian recreational fishing locations, as identified in a 2012 inland fishing survey conducted by the Victorian Fisheries Authority, are logistically able to receive water for the environment.[1977, 1978] Water delivered to Victorian rivers helps increase fish habitat, foraging and increases 'connectivity' which enables fish to move up and down stream (and onto the floodplain) to feed and breed.[1979]

As reported by Better Boating Victoria and the Victorian Fisheries Authority in 2020, 1,113,506 Victorians participated in recreational fishing across the state in 2018-19. These anglers made 6.8 million recreational fishing trips across Victoria, with almost half of these trips occurring in regional areas. An estimated $338 was spent per angler on each trip, with most of the spending on food, accommodation and transport in Victoria. Although the analysis didn't focus on water for the environment, the reported estimates still provide an indication of the benefits that environmental watering is likely to contribute to.

Recreational fishing in Victoria in 2018-19 generated $7.51 billion combined direct and indirect output, and $3.49 billion combined direct and indirect value added. Over the next 20 years, recreational fishing in Victoria is projected to generate $97.24 billion combined direct and indirect output, $45.27 billion combined direct and indirect value added.

Considering economic, recreational, social and Aboriginal cultural values in decisions to deliver water for the environment

Waterway managers work with communities to identify the cultural, economic, recreational, social and Aboriginal cultural values and uses of waterways. Managers also consider these values and uses within regional catchment and regional waterway strategies, environmental water management plans and seasonal watering proposals. Opportunities to support these values and uses are incorporated into watering decisions, provided they do not compromise environmental outcomes.

1975. A series of nine water recovery scenarios (through a combination of increased environmental entitlements in the Barwon and Moorabool Rivers and adjusted releases from the Ballarat South Wastewater Treatment Plant) were modelled.
1976. Corangamite Catchment Management Authority (CMA) 2021, 'River flows and their social and economic value for the Barwon and Moorabool rivers in Geelong', https://www.ccmaknowledgebase.vic.gov.au/soilhealth/maynard/view_resource.php?resource_id=4898&account=3817ce75cf365e79fc5aad26383c6347 Accessed 30 August 2022.
1977. Victorian Fisheries Authority (VFA), 'Inland fishing survey', https://vfa.vic.gov.au/recreational-fishing/future-content/inland-fishing-survey Accessed 29 July 2022.
1978. Victorian Environmental Water Holder (VEWH), 'Community benefits', https://www.vewh.vic.gov.au/water-for-the-environment/shared-community-benefits Accessed 29 July 2022.
1979. Ibid.

Inland waters — Water resources

Within the Seasonal Watering Plans that are published annually by the VEWH, specific watering actions planned to align with a social or recreational objective, or to be planned and/or delivered in partnership with Traditional Owners to support Aboriginal cultural values and uses, are clearly identified. For the 2022-23 Seasonal Watering Plan, the cultural, social and recreational objectives were:

- watering planned and/or delivered in partnership with Traditional Owners to support Aboriginal cultural values and uses
- watering planned to support water sports activities (e.g. canoeing, kayaking, rowing, swimming, water skiing)
- watering planned to support waterbird-related recreational activities
- watering planned to support angling activities
- watering planned to support peaks in visitation (e.g. camping or other public activities on long weekends or school holidays).

Within its annual reports, the VEWH publishes aggregated data on the number of watering actions that consider Aboriginal cultural values and uses of waterways and specific watering actions that consider social and recreational values and uses of waterways. This information for 2020-21 is presented below in Table WR17.

Table WR17: The number of specific watering actions that consider economic, recreational, social and Aboriginal cultural values.[1980]

Outcome measures	Achievement / comment
The Seasonal Watering Plan published by 30 June annually reports on: • Specific watering actions that consider Aboriginal cultural values and uses of waterways. • Specific watering actions that consider social and recreational values and uses of waterways.	The Seasonal Watering Plan for 2021-22 identified 286 potential watering actions, including: • At least 35 watering actions (12% of the total watering actions identified for 2021-22) planned with or intended to be delivered in partnership with Traditional Owners to support Aboriginal cultural values and uses. • Potential adjustments to the timing or management of planned environmental flows for at least 24 watering actions (8%) to support social and recreational values and uses of waterways. • Consideration of how environmental flows can support at least 57 different social, economic, recreational values across Victoria, such as fishing, birdwatching, community events and farming.

Despite the clear incorporation of cultural, economic, recreational, social and Aboriginal cultural values into watering planning and decisions, there is no consolidated quantification at a statewide scale of community outcomes achieved from environmental water delivery.

1980. Victorian Environmental Water Holder (VEWH) 2021, 'Annual report 2020-21', Melbourne, Victoria, https://www.vewh.vic.gov.au/__data/assets/pdf_file/0006/544461/VEWH-Annual-Report-2020-21.pdf Accessed 24 June 2022.

Commissioner
for Environmental
Sustainability
Victoria

Energy (E)

Victorian State of the Environment 2023 Report

Large rows of solar panels in a solar farm outside of Melbourne.
Credit: Tracie Louise.

Energy

Key findings

Measured globally, the energy sector is responsible for almost three-quarters of all greenhouse gas (GHG) emissions. The proportionate role of energy in emissions is even greater in Australia, and greater still in Victoria. This is due to the dominance of coal in Australia's electricity generation and the use of emission-intensive brown coal in Victoria. In 2022 the Victorian Government committed to bringing forward its net zero-emissions target by five years to 2045, meaning that Victoria will need to track slightly ahead of the International Energy Agency's (IEA) progress indicators.

Only one energy indicator received a status assessment of good in 2023, with three indicators rated as fair and two as poor (Table E1). However, the 2023 assessments are a significant improvement compared with the State of the Environment (SoE) 2018 Report. In 2018, eight out of the nine energy indicators were rated as poor. The indicator trends in 2018 were generally assessed as improving, which is consistent with the upgrade in status assessments reported in 2023.

Indicator 'E:01 Primary energy consumption' highlights that Victoria performs well relative to Australia by consuming less energy per capita and producing fewer GHG emissions from the energy sector per capita. While this is positive, per-capita energy consumption remains high relative to most G20 countries.

Critically, even though the energy sector in Victoria achieved a significant reduction (36%) of GHG emissions per capita during the past decade (2010–20) – a larger percentage reduction than any other Australian state or territory during that period – a much greater reduction (68%) is required during the next decade to meet the IEA's 2030 progress target for the objective of net zero emissions by 2050.[1981]

An increase in the use of renewables in electricity production is driving the environmental improvements in the energy sector. Indicator 'E:04 Electricity generation by fuel' shows that renewable sources of Victorian electricity have increased from 6% in 2008-09 to 30% in 2020–21, while coal has dropped from 92% in 2008-09 to 66% in 2020–21. The Victorian Government's legislated renewable energy target — 25% of electricity in Victoria produced from renewable sources by 2020 — has been met. However, further improvements are now needed to reach the next target of 40% by 2025. Furthermore, the Victorian Government has committed to increase its 2030 target from 50% renewable electricity generation to 65%, and to legislate a new target of 95% by 2035 — highlighting that the next decade is a critical period for renewable energy transition in Victoria.[1982] The power system is rapidly decentralising, and it will be valuable for the Victorian Government to establish and publish data to track the progress to/of variable renewable generation (i.e. solar and wind power).

Despite the gains by renewables for electricity production, emissions from fossil fuel fired-electricity generation accounted for 41.7 Mt CO2-e in 2020, which was about half (50.1%) of Victoria's total net emissions. Coal remains the dominant fuel source for electricity generation in Victoria, which offsets the relatively high penetration of renewable sources when benchmarked against G20 countries.

There has only been a small decline in per-capita gas consumption (E:05) in Victoria (compared to electricity) and an under-performance in Victoria relative to South Australia and New South Wales for per-capita gas distribution. With gas prices rising steadily, GHG emissions from residential fuel combustion increasing, and international events causing uncertainty in gas supply and price around the world, reducing gas consumption and associated GHG emissions is an important and immediate focus for Victoria. Over two million Victorian homes and businesses use gas — more than any other state or territory.[1983] To effectively monitor the transition from natural gas in residential water heating and space heating, it will be critical to report data on the energy consumed by water heaters installed in each year, and in the total residential sector, classified by fuel type.

[1981] In 2022 the Victorian Government committed to bring forward its net zero emissions target by five years to 2045, which means that Victoria will need to track ahead of the IEA progress indicators.

[1982] Department of Energy, Environment and Climate Action (DEECA), 'Victorian renewable energy and storage targets', https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets Accessed 15 February 2023.

[1983] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victoria's gas substitution roadmap', https://www.energy.vic.gov.au/renewable-energy/victorias-gas-substitution-roadmap Accessed 9 June 2023.

Energy

Victoria's performance in energy consumption (and GHG emissions) in transport (E:06) is poor by comparison to GHG emissions in stationary energy. Energy use and GHG emissions from transport are both lower than the previous state of the environment reporting period; however, this is more likely due to a reduction in travel associated with the COVID-19 restrictions rather than factors that would contribute to an enduring change.

Unlike total energy consumption per capita from all sectors, which has declined year-on-year in Victoria since 2009 (except for a minor increase in 2018), energy consumption from the transport subsector had not been distinctly decoupling from population growth — at least until the COVID-19 pandemic, when travel restrictions and substantial reductions in energy consumption from transport occurred in both 2019–20 and 2020–21. There have been no significant changes in GHG efficiency in the transport sector since data were first available in 1990.

To reduce GHG emissions from the transport subsector, fossil fuel energy use per person needs to decline at a faster rate than population growth, and technological advancements must reduce GHG emissions from transport.

Wind farm near Hamilton, Victoria.
Credit: John Carnemolla.

Table E1: Energy indicators assessed in this chapter with comparisons to SoE 2018 assessments.

Theme: Energy

2023 Indicator	2023 status	2023 trend	2023 confidence	2018 Indicator	2018 status	2018 trend	2018 data quality
E:01 Primary energy consumption	🟡	↗	🟢	E:02 Total energy consumption by fuel	🔴	→	🟢
E:02 Primary energy consumption by source	🟡	↗	🟢	E:02 Total energy consumption by fuel	🔴	→	🟢
E:03 Electricity consumption	🟢	↗	🟢	E:05 Total electricity consumption	🟡	↗	🟢
E:04 Electricity generation by fuel	🟡	↗	🟢	E:06 Total electricity generation by fuel	🔴	↗	🟢
E:05 Gas consumption	🔴	→	🟢	New SoE 2023 indicator	New SoE 2023 indicator	New SoE 2023 indicator	New SoE 2023 indicator
E:06 Energy in transport	🔴	↗	🟢	E:08 Energy used in the transport sector	🔴	↙	🟢

Victorian Government progress on State of the Environment 2018 Report recommendations

The SoE 2018 Report included recommendations to the Victorian Government to improve environmental sustainability outcomes. Presented below are the recommendations specific to this theme as well as:

- the full government response to the recommendations, including the level of support, as published in the Victorian Government Response to the State of the Environment 2018 Report
- a description of progress made on the implementation of the recommendation over the past five years. The content of this section is derived from written material supplied directly to the Commissioner for Environmental Sustainability by relevant government entities and/or it synthesises information that is publicly available in referenced reports, legislation and websites. Importantly, this section summarises the progress made since 2018 in relation to the recommendation; it is not an audit of the extent and quality of the completed work.

Recommendation 15 of the SoE 2018 Report recommended:

> *That DELWP establish indicators, and implement measures to collect appropriate data, to track the impact of energy emissions reduction to meet interim targets set under the Climate Change Act 2017. The reporting should also track the transition of Victoria's grid, transport and industry infrastructure to support a low-carbon future.*

Government response in 2020:

SUPPORT

> 'The *Climate Change Act 2017* requires the Government to publish an annual greenhouse gas emissions inventory report for Victoria. This provides a transparent account of sources and trends of Victoria's greenhouse gas emissions across all sectors of the economy, including electricity generation, transport, and industrial processes sectors. The *Climate Change Act 2017* also requires the Government to publish a report at the end of each interim target period which states whether the interim emissions reduction targets have been achieved and assesses the implementation and effectiveness of the emissions reduction pledges.' [1984]
>
> 'The *Climate Change Act 2017* sets a target of net zero greenhouse gas emissions by 2050 and requires the establishment of five-yearly interim greenhouse gas emission reduction targets to support the transition to net zero emissions. The Government is in the process of determining statewide interim emissions reduction targets for 2021-2025 and 2026-2030, along with policies and programs to achieve the emissions reduction targets.' [1985]

Progress made since 2018

As required under the *Climate Change Act,* the Victorian Greenhouse Gas Emissions Report has been published every year since 2018 and is available publicly on DEECA's website.[1986] The report includes data on Victoria's main emissions sources by sector, including emissions from energy. The most recent report for 2020, published in September 2022, shows Victoria's total net emissions fell by 29.8% between 2005 and 2020, to reach 83.3 Mt CO2-e in 2020.[1987] This emissions reduction went beyond the state's target to cut emissions 15% to 20% below 2005 levels by 2020.

[1984] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian Government response to the state of the environment 2018 report', Melbourne, Victoria.

[1985] Ibid.

[1986] Department of Energy, Environment and Climate Action (DEECA), 'Greenhouse gas emissions', Melbourne, Victoria, https://www.climatechange.vic.gov.au/victorias-greenhouse-gas-emissions-and-targets Accessed 15 February 2023.

[1987] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian greenhouse gas emissions report 2020', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0036/598257/Victorian-Greenhouse-Gas-Emissions-Report-2020.pdf Accessed 20 October 2022.

Energy

Victoria's interim target for the period 2021–2025 is for emissions to reduce 28% to 33% below 2005 levels by the end of 2025. The interim target for the period 2026 to 2030 is for emissions to reduce 45% to 50% below 2005 levels by the end of 2030. These interim targets were published in May 2021 with Victoria's Climate Change Strategy, which outlined policies and programs to achieve these targets, including pledges for each sector of the economy and government emissions.[1988]

As required by the Climate Change Act, the Government will publish a report at the end of each interim target period which states whether the interim emissions reduction targets have been achieved and assesses the implementation and effectiveness of the emissions reduction pledges, including the Victorian energy and transport sector pledges.

In 2022, the Victorian Government committed to an emissions reduction target of 75% to 80% by 2035, and to bring forward its net zero emissions target by five years to 2045.[1989] The government intends to legislate the targets for 2035 and 2045 in 2023.[1990]

Recommendation 16 of the SoE 2018 Report recommended:

> *That DELWP implement measures to collect data and track the impact of the transition to a low-emission electricity system on (i) consumer sentiment and behaviour, (ii) investment in distributed, low and zero-emissions electricity generation, and (iii) the associated markets, governance and business models.*

Government response in 2020:

SUPPORT

> 'The Victorian Government is designing and implementing a range of policy and regulatory reforms to modernise our electricity system and support the transition to a more affordable, reliable and clean energy system. The Government notes the importance of tracking this transition.' [1991]

Progress made since 2018

Under Section 8 of the *Renewable Energy (Jobs and Investment) Act 2017*, the Victorian Minister for Energy and Resources provides an annual report to the Parliament of Victoria on progress made towards achieving Victoria's renewable energy targets, the performance of schemes to achieve the targets and economic activity in Victoria's renewable energy sector. The fifth report under this legislation was tabled in the Parliament of Victoria in December 2022 and is publicly available.[1992]

Solar Victoria has established a Voice of Customer program to survey and gather feedback on consumer sentiment and behaviour from Solar Victoria rebate customers. Solar Victoria conducts regular online surveys of rebate customers to better understand how adoption of renewable and energy-efficient technologies has affected their energy usage, energy costs, and propensity to invest in complementary technologies to maximise the benefits from their systems.

Further commentary on data collection, collation and analysis for relevant datasets is provided in the 'Recommendations' within Part 1 of this report.

[1988] Department of Environment, Land Water and Planning (DELWP) 2021, 'Victoria's climate change strategy', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0026/521297/Victorian-Climate-Change-Strategy.pdf Accessed 22 July 2022.

[1989] The Hon Daniel Andrews MP 2022, 'Putting power back in the hands of Victorians', Media Release 20 October 2022.

[1990] Department of Energy, Environment and Climate Action (DEECA), 'Climate action targets', Melbourne, Victoria, https://www.climatechange.vic.gov.au/climate-action-targets Accessed 20 October 2022.

[1991] Department of Environment, Land, Water and Planning (DELWP), ' Victorian Government response to the State of the Environment 2018 report ', Melbourne, Victoria.

[1992] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian Renewable Energy Target 2021/22 Progress Report', Melbourne, Victoria, https://www.parliament.vic.gov.au/file_uploads/VRET_2021-22_Progress_Report_Ptn9bZs8.pdf Accessed 15 February 2023.

Energy

Background

Measured globally, the energy sector is responsible for almost three-quarters of the GHG emissions that have already pushed global average temperatures 1.1°C higher since the pre-industrial age, with visible impacts on weather and climate extremes.[1993] The proportionate role of energy in emissions is even higher in Australia, and higher still in Victoria relative to Australia. This is due to the dominance of coal in electricity generation in Australia and the use of highly emission-intensive brown coal in Victoria.

In 2021, the International Energy Agency (IEA) identified four measures to achieve the 'low emissions revolution' that it says 'is long overdue':

- 'A massive additional push for clean electrification … accelerating the decarbonisation of the electricity mix is the single most important lever.' [1994]
- 'A relentless focus on energy efficiency.' [1995]
- 'A broad drive to cut methane emissions from fossil fuel operations.' [1996]
- 'A big boost to clean energy innovation.' [1997]

The IEA's modelling of net zero emissions from the energy sector by 2050 identifies many indicators of progress that are consistent with the objective for net zero emissions by 2050. A selection of these indicators is summarised below in Table E2. It is important to note that, in 2022, the Victorian Government committed to bringing forward its net zero emissions target by five years, to 2045, which will mean Victoria will need to be tracking slightly ahead of the progress indicators shown in Table E2.[1998]

Table E2: IEA Net Zero by 2050 indicators.[1999]

IEA indicator	2030	2040	2050
CO_2 emissions per capita in advanced economies (tonnes CO_2 per capita)	4	1	0
CO_2 emission intensity of electricity generation (grams CO_2 per kWh)	138	-1	-5
Share of unabated coal in electricity generation (%)	8	0	0
Share of renewables in electricity generation (%)	61	84	88
Share of wind and solar PV (%)	40	63	68

This chapter sets out information and evidence to support conclusions on how the energy sector is impacting the state of the environment in Victoria.

The IEA Net Zero indicators have been incorporated as measures to guide assessments of the six indicators in this chapter (Table 1). The assessments are, primarily, comparative not absolute. The comparison is with respect to the Group of Twenty (G20) large economies and, where relevant, to other states of Australia that are part of the National Electricity Market (NEM). Furthermore, the indicator summaries in this chapter are not an assessment of the Government's policies.

The indicators in this chapter are primarily focussed on GHGs, which is the dominant environmental issue for the Victorian energy sector. From this perspective, outcomes associated with fewer GHG emissions — such as those arising from lower consumption or less fossil fuel generation — are counted favourably and the converse unfavourably. Lower consumption can imply a loss of utility by customers or a loss of production by producers, therefore, environmental gains may come at the expense of consumers or producers, although the initial evidence does not suggest that this is the case.

[1993] International Energy Agency 2021, 'World energy outlook 2021', Paris, France.
[1994] Ibid.
[1995] Ibid.
[1996] Ibid.
[1997] Ibid.
[1998] The Hon Daniel Andrews MP 2022, 'Putting power back in the hands of Victorians', Media Release 20 October 2022.
[1999] International Energy Agency 2021, 'World energy outlook 2021', Paris, France.

For example, Figure E1 shows that over the 12 years between 2008-09 and 2020-21, primary energy consumption per person declined by 35% and gross state product (GSP) per unit of primary energy increased by 62%.[2000] This shows that much lower primary energy consumption per person has been achieved in conjunction with much higher GSP per unit of primary energy.

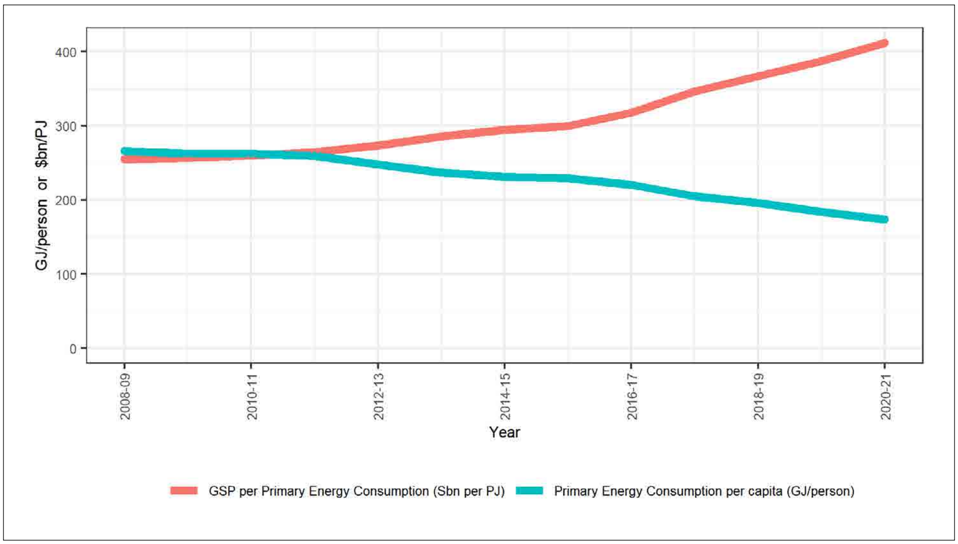


Figure E1: Primary energy consumption per capita (GJ/person) and GSP per unit of primary energy consumption ($billion per PJ) in Victoria from 2008-09 to 2019-20.[2001]

As detailed in indicator 'CC:11 Annual greenhouse gas emissions', it is clear that a substantial task lies ahead to reduce emissions in Victoria, and that the energy sector — mainly electricity generation but also energy in transport — will be the main focus. The indicator assessments in this chapter show that Victoria is tracking well at decreasing the proportion of electricity generated by fossil fuels, although there is still a large task ahead. There is also a substantial task ahead for transport, but little progress has been made in that sector.

There are other environmental issues, besides GHGs, that are associated with energy production and consumption. These are not included in this analysis. Examples of such adverse environmental impacts include, in the case of fossil fuel use, land contamination, hazard (ash) disposal, water consumption and river system effects. While for renewables, adverse effects can include impacts on fauna (particularly avian) and loss of biodiversity. Additionally, the construction of new transmission lines can potentially impact the productivity of land.

Policy and legislative settings

Shortly before the publication of the SoE 2018 Report, the Victorian Government determined interim targets to reduce emissions by 28% to 33% below 2005 levels by 2025, and 45% to 50% by 2030.[2002] In 2022, the Victorian Government committed to an emissions reduction target of 75% to 80% by 2035, and to bring forward its net zero emissions target by five years to 2045.[2003] The government intends to legislate the targets for 2035 and 2045 in 2023.[2004]

2000. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2001. Ibid.
2002. Department of Energy, Environment and Climate Action (DEECA), 'Climate action targets', Melbourne, Victoria, https://www.climatechange.vic.gov.au/climate-action-targets Accessed 20 October 2022.
2003. The Hon Daniel Andrews MP 2022, 'Putting power back in the hands of Victorians', Media Release 20 October 2022.
2004. Department of Energy, Environment and Climate Action (DEECA), 'Climate action targets', Melbourne, Victoria, https://www.climatechange.vic.gov.au/climate-action-targets Accessed 20 October 2022.

Energy

Also, shortly before the publication of the SoE 2018 Report, the Government legislated renewable energy targets (the proportion of electricity in Victoria to be produced from renewable sources) of 25% by 2020, 40% by 2025 and 50% by 2030.[2005] The 2020 renewable electricity target was achieved. As part of its 2022 emissions reduction commitments, the Victorian Government also stated it will increase its 2030 target from 50% renewable electricity generation to 65%, and that it will set a new target of 95% renewable electricity generation by 2035.[2006] As at May 2023, the net zero emissions target remains at 2050 under the *Climate Change Act*, while the renewable energy targets in the *Renewable Energy Act* remain at 40% by 2025 and 50% by 2030.[2007, 2008]

Victoria's first Climate Change Strategy was published in 2021 and the Victorian Government prepared emissions reduction pledges for 2021 to 2025 — the first in a progression of five-yearly pledges required under the Climate Change Act.[2009, 2010] The Victorian Government estimated that the full suite of actions in the energy sector pledge will reduce emissions across the National Electricity Market by 4.1 Mt CO2-e in 2025 and 7.5 Mt CO2-e in 2030. This includes emissions reductions in Victoria of 2.2 Mt CO2-e in 2025 and 3.7 Mt CO2-e in 2030.[2011]

As part of the Victorian Government's Budget for 2023-24, released in May 2023, a $1 billion investment will be made to re-establish the State Electricity Commission (SEC) and accelerate the replacement of coal with renewable energy.[2012]

To help meet the renewable energy targets, the Victorian Government contracted more than 800 MW of renewable generation for projects that have been completed in its first renewable energy auction in 2018. As part of a second auction, six projects were contracted in 2022 for a planned 623 MW of new renewable capacity and 365 MW of energy storage capacity.[2013]

To further support Victoria's renewable energy transition, the Government announced in 2022 an intention to legislate Victorian energy storage targets of at least 2.6 GW of energy storage capacity by 2030 and at least 6.3 GW by 2035.[2014] The Victorian Government has also been contracting with what is now the Southern Hemisphere's largest operational battery, and is supporting the development of batteries connected to distribution networks and situated on customers' premises.[2015, 2016]

In 2023, a Ministerial Order was implemented to progress the Victoria-New South Wales Interconnector (VNI) West project, which will better connect the Victoria and NSW energy grids.[2017] VNI West is a 500kV transmission line that will connect the Victorian and NSW grids, aiming to provide reliable electricity access during high demand periods, and allowing for around 3.4 gigawatts of additional renewable generation to be built across the solar-rich Murray River Renewable Energy Zone (REZ) and wind-rich Western Victoria REZ.

Shortly after the SoE 2018 Report was published, the Government introduced rebates for the installation of solar photovoltaic (PV) panel, battery and hot water systems under its Solar Homes program.[2018] Data provided by Solar Victoria for this report shows that 1,450 MW of PV panel capacity had been installed by the end of 2022, while there is 134 MWh of home battery storage from 11,460 installations that received Solar Victoria rebates.

[2005] State Government of Victoria 2020, '*Renewable Energy (Jobs and Investment) Act 2017*'', Authorised Version No. 002 incorporating amendments as at 13 August 2020.

[2006] Department of Energy, Environment and Climate Action (DEECA), 'Victorian renewable energy and storage targets', Melbourne, Victoria, https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets Accessed 15 February 2023.

[2007] State Government of Victoria 2022, '*Climate Change Act 2017*'', Authorised Version No. 008 incorporating amendments as at 1 July 2022.

[2008] State Government of Victoria 2020, '*Renewable Energy (Jobs and Investment) Act 2017*'', Authorised Version No. 002 incorporating amendments as at 13 August 2020.

[2009] Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victoria's climate change strategy', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0026/521297/Victorian-Climate-Change-Strategy.pdf Accessed 22 July 2022.

[2010] Department of Environment, Land Water and Planning (DELWP) 2021, 'Energy sector emissions reduction pledge', Melbourne, Victoria, https://www.climatechange.vic.gov.au/victorian-government-action-on-climate-change/Energy-Sector-Pledge-Accessible.pdf Accessed 15 February 2023.

[2011] Ibid.

[2012] State Government of Victoria, 'For the good of all Victorians, for good', https://www.budget.vic.gov.au/good-all-victorians-good Accessed 26 May 2023.

[2013] Department of Energy, Environment and Climate Action (DEECA), 'Victorian renewable energy target auction (VRET2)', Melbourne, Victoria, https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets/victorian-renewable-energy-target-auction-vret2 Accessed 15 February 2023.

[2014] Department of Energy, Environment and Climate Action (DEECA), 'Victorian renewable energy and storage targets', Melbourne, Victoria, https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets Accessed 15 February 2023.

[2015] Department of Energy, Environment and Climate Action (DEECA), 'Victorian big battery', Melbourne, Victoria, https://www.energy.vic.gov.au/renewable-energy/batteries-energy-storage-projects/victorian-big-battery Accessed 15 February 2023.

[2016] State Government of Victoria 2022, 'Media release: Australia's biggest renewable energy storage targets', Melbourne, Victoria, https://www.premier.vic.gov.au/sites/default/files/2022-09/220927%20-%20Australia%E2%80%99s%20Biggest%20Renewable%20Energy%20Storage%20Targets_0.pdf Accessed 8 November 2022.

[2017] State Government of Victoria 2023, 'Media release: Taking action to deliver critical energy infrastructure', Melbourne, Victoria, https://www.premier.vic.gov.au/taking-action-deliver-critical-energy-infastructure Accessed 29 May 2023.

[2018] Solar Victoria, 'Solar Homes Program reporting', Morwell, Victoria, https://www.solar.vic.gov.au/solar-homes-program-reporting Accessed 8 November 2022.

Energy

In energy efficiency, the Government's Victoria Energy Upgrades program reduces GHGs by providing access to discounted energy efficient products and services. The program has annual targets, including a 6.5 million tonnes of CO_2-e reduction in 2021, which rises to a 7.3 million tonnes of CO_2-e reduction by 2025.[2019]

In transport, some policies to encourage electrification and efficiency have been adopted. These include:

- the release of a Zero Emissions Vehicle (ZEV) Roadmap in May 2021, which includes a $100 million support package to accelerate the uptake of ZEVs.
- an increase in the active transport mode share to 25% by 2030.
- subsidisation of the purchase of 20,000 ZEV over three years from mid-2021.
- $19 million of funding for charging infrastructure across regional Victoria
- $10 million of funding to add 400 ZEV to the Victorian Government fleet by 2023
- the requirement that all new public transport bus purchases are to be ZEVs from 2025, supported by a $20 million ZEV bus trial.[2020, 2021, 2022, 2023, 2024, 2025]

Over 2 million Victorian homes and businesses use gas — more than any other Australian state or territory. With gas prices rising steadily, GHG emissions from residential fuel combustion increasing and international events causing uncertainty in gas supply and price around the world, reducing gas consumption and associated GHG emissions within Victoria's gas sector is an important and immediate focus area for Victorian energy policy.[2026] This led the Victorian government to releasing a Gas Substitution Roadmap in 2022 that details how the state can use energy efficiency, electrification, hydrogen and biogas to reduce emissions from gas over time.[2027]

On 28 July 2023, the Victorian Government announced that all new Victorian homes from 1 January 2024 will only connect to all electric networks, phasing out gas in new homes.[2028]

[2019] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian Energy Upgrades program - Response to consultation on program targets for 2021 to 2025', Melbourne, Victoria, https://engage.vic.gov.au/download/document/9812 Accessed 20 October 2022.

[2020] Department of Environment, Land Water and Planning (DELWP) 2021, 'Victoria's zero emissions vehicle roadmap', Melbourne, Victoria, https://www.energy.vic.gov.au/__data/assets/pdf_file/0031/583726/Zero-emission-vehicle-roadmap.pdf Accessed 15 February 2023.

[2021] Department of Environment, Land Water and Planning (DELWP) 2021, 'Transport sector emissions reduction pledge', Melbourne, Victoria, https://www.climatechange.vic.gov.au/victorian-government-action-on-climate-change/Transport-sector-pledge-accessible.pdf Accessed 15 February 2023.

[2022] Ibid.

[2023] Ibid.

[2024] Ibid.

[2025] Ibid.

[2026] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian greenhouse gas emissions report 2020', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0036/598257/Victorian-Greenhouse-Gas-Emissions-Report-2020.pdf Accessed 20 October 2022.

[2027] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Gas Substitution Roadmap', Melbourne, Victoria, https://www.energy.vic.gov.au/__data/assets/pdf_file/0025/586411/Victorias-Gas-Substitution-Roadmap.pdf Accessed 20 October 2022.

[2028] Premier of Victoria 2023, 'New Victorian homes to go all electric from 2024', https://www.premier.vic.gov.au/new-victorian-homes-go-all-electric-2024 Accessed 3 August 2023.

Indicator assessments

Refer to 'Guide to the indicator assessments' at the start of Part 3 for the accompanying definitions and legends related to the indicator assessment summary tables.

SoE indicator suite adjustments

State of the environment indicators are the foundational tools for evaluating and communicating the impact our activities have on the environment. The assessments of SoE 2018 indicators provided a scientific baseline of the state of Victoria's environment from which future SoE reports build upon.

However, as new pressures, challenges and data sources emerge, the SoE indicator suite must also evolve to ensure their collective assessments provide a comprehensive account of the condition of Victoria's natural values. The SoE 2023 indicator suite has been adjusted, with some new indicators being introduced and some existing indicators either being disaggregated to improve the focus of assessments, merged to enable inter-connected indicators to be evaluated as a whole, superseded, or modified in terms of the scope, breadth of measures or to align with policy targets. Refer to Appendix C of the Summary Report for a complete account of the changes that have been made to the SoE 2018 indicator suite in this report.

Changes to the indicator suite for this chapter are outlined below.

- The new SoE 2023 indicator 'E:05 Gas consumption' has been introduced.
- The SoE 2018 indicators 'E:03 Consumption of renewable energy as a share of total energy consumption', 'E:04 Total net energy consumption by industry sector', 'E:07 Share of renewable energy generation of total electricity generation' and 'E:09 Per capita transport energy use' have been considered within the overall assessments of the SoE 2023 indicators, however, direct comparisons were not made against the 2023 indicator assessments within the summary tables.

Yallourn Power Station in LaTrobe Valley, Victoria to be closed in 2028.
Credit: Vanessa Jones.

Energy

Indicator E:01 Primary energy consumption

E:01 Primary energy consumption						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🟡	↗	🟢	🔴	→	🟢
Data source(s):	BP, DCCEEW					
Measure(s):	Primary energy consumption Primary energy consumption per capita GHG emissions from the energy sector GHG emissions from the energy sector per capita					

Why this indicator?

Victoria's primary energy system is by far the most significant source of the state's GHG emissions. This indicator is designed to analyse Victoria's energy consumption and consequent emissions, and to assess whether the state is making progress towards net zero GHG emissions.

NB: This SoE 2023 indicator was 'E:02 Total energy consumption by fuel' in the SoE 2018 Report.

Why this assessment in 2023?

The status for this indicator has been assessed as fair due to primary energy consumption per capita in Victoria remaining high relative to most G20 countries, but low relative to the national figure. Furthermore, even though a significant reduction (51%) of GHG emissions per capita from the energy sector was achieved during the past decade, an even greater reduction (68%) is required during the next decade to meet the International Energy Agency's (IEA) 2030 progress target for the objective of net zero emissions by 2050.

Despite the fair rating for the status of this indicator, the substantial reductions in primary energy consumption and GHG emissions from the energy sector, particularly over the most recent decade, are the basis for the improving trend assessment for this indicator.

Summary of State of the Environment 2018 Report assessment

- The data suggested that energy consumption had not yet decoupled from population and economic growth.
- Energy use per capita had declined to slightly below 1990 levels but remained high by global standards.

Critical data used for the 2023 assessment

- Australian Energy Update 2022 (Table B and Table C)
- Australian Greenhouse Emissions Information System
- BP Statistical Review of World Energy 2022

2023 assessment

The data on Victoria's energy production, consumption and consequent emissions suggests the state is making progress towards net zero GHG emissions from the energy sector but needs considerable improvements to be on-track with the IEA projections to reach net zero GHG emissions from the energy sector by 2050.[2029]

In Victoria, primary energy consumption has decreased by 22% during the most recent decade of data (2010-11 to 2020-21) despite an 18% increase in population.[2030, 2031] By comparison, the primary energy consumed for Australia as whole decreased by 2% while the national population increased by 15%.

[2029] It is important to note that, in 2022, the Victorian Government committed to bring forward its net zero emissions target by five years to 2045, which will mean Victoria will need to be tracking slightly ahead of the IEA progress indicators.

[2030] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.

[2031] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table C, September 2022', Canberra, Australia.

Energy

The decrease in primary energy consumption in Victoria is reflected by decreasing GHG emissions from the energy sector in the state during the past decade (2010-2020), when Victoria's energy emissions reduced by 23%. This was a positive performance relative to the national data, with Australia's energy sector emissions in 2020 remaining unchanged (that is, within 1%) from the 2010 emissions total.

The promising results for Victoria during the past decade are balanced against two decades of generally increasing GHG emissions from the energy sector that persisted from 1990 to 2010, which led to a 34% increase in the state's energy sector GHG emissions from 1990 to 2010 (Figure E2). During the same period, Australia's energy sector GHG emissions increased by 42%. Victoria's emissions from the energy sector comprised 27% of Australia's emissions during 1990, and this was reduced to 19% by 2020. Over the full three-decade period (1990-2020), Victoria's energy emissions have increased by 3% and Australia's have increased by 41%.[2032, 2033]

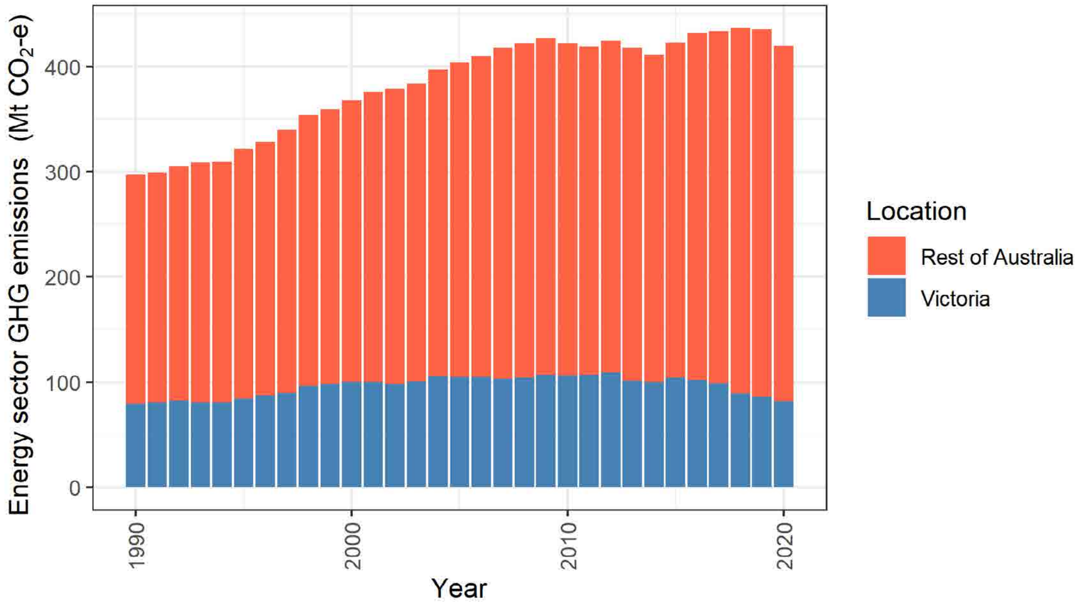


Figure E2: Total energy sector GHG emissions (mega tonnes CO2-e) in Victoria and the rest of Australia from 1990 to 2020.[2034]

Primary energy consumption per capita

Table E3 shows primary energy consumption per capita in Victoria, Australia and other G20 countries.

In 2011, Australia was ranked 16th out of the 19 G20 countries in terms of primary energy consumption per capita.[2035] If Victoria was a country, in 2011 it would have ranked slightly worse than Australia for primary energy consumption per capita in the G20 cohort.[2036, 2037]

[2032] Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Australian greenhouse emissions information system', Canberra, Australia, http://ageis.climatechange.gov.au Accessed 20 October 2022.

[2033] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian greenhouse gas emissions report 2020', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0036/598257/Victorian-Greenhouse-Gas-Emissions-Report-2020.pdf Accessed 20 October 2022.

[2034] Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Australian greenhouse emissions information system', Canberra, Australia, http://ageis.climatechange.gov.au Accessed 20 October 2022.

[2035] British Petroleum (BP) 2022, 'BP statistical review of world energy 2022 | 71st edition', London, United Kingdom, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf Accessed 20 October 2022.

[2036] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.

[2037] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table C, September 2022', Canberra, Australia.

Energy

By 2021, Victoria had improved its standing slightly to be ranked 14th. Promisingly, Victoria's per capita primary energy consumption has declined by 30% from 2011 to 2021, which is a greater per capita reduction than any of the G20 countries. Australia's per capita primary energy consumption has declined by 11% over the same period, while the biggest decline in the G20 was Mexico, with a 21% decrease.

Table E3: Comparison of primary energy consumption per capita (GJ/person) among G20 countries and Victoria between 2011 and 2021.[2038, 2039, 2040]

G20 countries	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Percent change from 2011 to 2021
Canada	409	405	411	408	408	397	399	397	389	363	364	-11%
Saudi Arabia	324	334	326	342	350	352	340	328	315	303	301	-7%
US	297	287	293	293	288	286	285	294	290	267	280	-6%
South Korea	231	232	232	233	236	242	244	248	244	234	245	6%
Australia	250	242	241	239	241	239	234	233	238	223	222	-11%
Russian Federation	202	202	199	199	196	200	200	208	206	198	215	6%
Victoria	277	270	260	253	250	245	231	217	207	198	195	-31%
Germany	166	168	173	165	166	168	169	165	160	149	152	-9%
France	165	164	164	157	157	154	152	155	151	136	144	-12%
Japan	157	156	155	151	149	147	149	149	146	136	141	-10%
China	82	85	88	90	90	91	94	97	100	103	109	33%
Italy	121	118	111	104	107	108	109	111	109	100	107	-11%
United Kingdom	134	135	133	125	126	124	122	121	118	105	107	-20%
South Africa	100	97	96	95	92	95	93	89	91	83	83	-17%
Turkey	66	69	67	68	73	76	79	77	79	76	80	22%
Argentina	79	81	84	83	83	82	81	80	75	70	75	-5%
Brazil	60	60	62	63	61	59	59	59	59	56	59	-2%
Mexico	66	66	65	64	63	63	64	63	59	50	52	-21%
Indonesia	28	28	27	27	27	27	28	31	32	30	30	9%
India	19	20	21	22	22	23	23	25	25	23	25	33%

Note: The data for the G20 countries in this table was taken from BP's Statistical Review of World Energy (2022). The primary energy consumption data published in that report included thermal equivalent efficiency factors used to convert non-fossil electricity (excluding biomass-powered electricity) to primary energy. These factors have been applied to the Victorian data (taken from Australian Energy Statistics Table B and Table C published in 2022) presented in this table to ensure consistency between Victoria's primary energy consumption and the primary energy consumption presented for each G20 country. As the BP's Statistical Review of World Energy (2022) contained annual data, Victoria's data are based on financial year data that has been averaged to derive annual values (e.g. the data for 2019-20 and 2020-21 have been averaged to calculate an annual primary energy consumption per capita value for 2020). Also note that the 2021 value for Victoria is based on 2020-21 data.

2038. British Petroleum (BP) 2022, 'BP statistical review of world energy 2022 | 71st edition', London, United Kingdom, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf Accessed 20 October 2022.
2039. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2040. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table C, September 2022', Canberra, Australia.

Figure E3 shows that Victoria's GHG emissions per capita from energy were similar to those of Australia from 1990 to 2015, before a significant reduction in Victoria that has not replicated to the same extent nationally — per capita emissions from the energy sector have fallen by 31% from 1990 in Victoria and 5% in Australia.[2041, 2042] Victoria's GHG emissions per capita from the state's energy sector have actually decreased by 41% since peaking in 2004. However, at 12.5 tonnes CO_2-e per capita in 2020, GHG emissions in Victoria are still more than three times higher than the IEA's indicator for 2030. GHG emissions per capita from the energy sector would need to reduce by 68% between 2020 and 2030 for Victoria's emissions to be on-track for net zero by 2050, in accordance with the IEA's progress indicators.

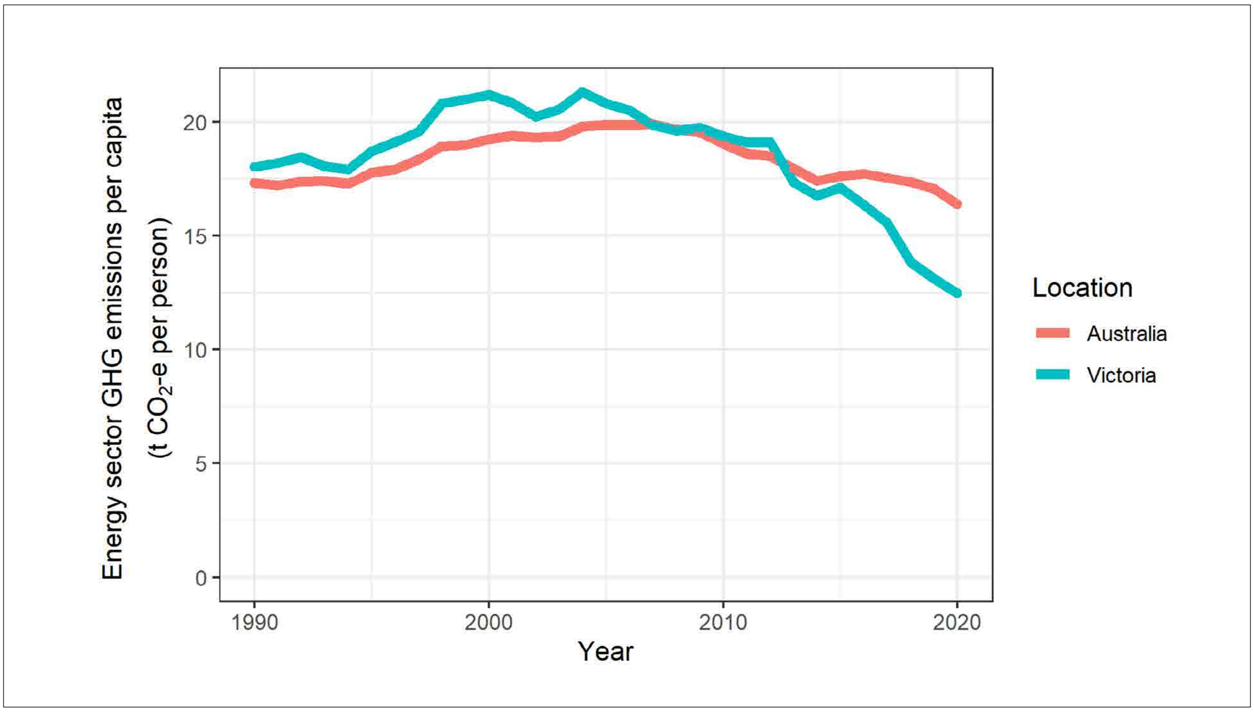


Figure E3: Total energy sector GHG emissions per capita (tonnes CO2-e/person) in Australia and Victoria from 1990 to 2020.[2043, 2044, 2045]

The status for this indicator has been rated as fair due to primary energy consumption per capita in Victoria remaining high relative to most G20 countries, but low relative to the national figure. Furthermore, even though a significant reduction of GHG emissions per capita from the Victorian energy sector was achieved during the past decade (a decline of 36%), an even greater reduction (68%) is required during the next decade to meet the IEAs 2030 progress target for the objective of net zero emissions by 2050.[2046]

Despite the fair rating for the status of this indicator, the substantial reductions in primary energy consumption and GHG emissions from the state's energy sector, particularly over the most recent decade, are the basis for the trend assessment of improving for this indicator. The improvement in Victoria is primarily due to coal generation closure (and replacement by renewables) as well as absolute energy efficiency improvements.

2041. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2042. Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Australian greenhouse emissions information system', Canberra, Australia, http://ageis.climatechange.gov.au Accessed 20 October 2022.
2043. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2044. Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Australian greenhouse emissions information system', Canberra, Australia, http://ageis.climatechange.gov.au Accessed 20 October 2022.
2045. Australian Bureau of Statistics (ABS), 'National, state and territory population', Reference period: March 2022, 3101.0 National state and territory population - TABLE 4. Estimated Resident Population, State and Territories (Number), Canberra, Australia, Accessed 24 November 2022.
2046. International Energy Agency 2021, 'World energy outlook 2021', Paris, France.

Energy

Indicator E:02 Primary energy consumption by source

E:02 Primary energy consumption by source

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	↗	🟢	🔴	→	🟢
Data source(s):	DCCEEW					
Measure(s):	Primary energy consumption in Victoria, by fuel source					

Why this indicator?

Meeting Victoria's climate change mitigation goals requires a large-scale energy transition.

Victoria will require an almost complete transformation of its energy system away from the current dominance of fossil fuels to low- and zero-emissions energy resources, if it is to transition to a net zero GHG emissions economy by 2050.

Why this assessment in 2023?

While the increasing substitution of coal for renewables in electricity production is positive and reflected in a trend assessment of improving for this indicator, the electricity generation, transport and fuel combustion subsectors remain responsible for more than 95% of Victoria's net GHG emissions, as of 2020. Because energy consumption from a range of fuels and subsectors comprises nearly all of Victoria's net GHG emissions, the status assessment for this indicator is fair, which is in line with the status assessment for indicator 'CCM:11 Annual greenhouse gas emissions' in this report.

Summary of State of the Environment 2018 Report assessment

- Victoria's energy system was highly fossil-fuel dependant.
- Energy consumption had increased across most sectors and remained primarily supplied by fossil fuels.
- The proportion of energy consumption from renewables was increasing. However, it still accounted for only a small share of total consumption, particularly in relation to the best performing jurisdictions in Australia or internationally.

Critical data used for the 2023 assessment

- Australian Energy Update 2022 (Table C)
- Australian Greenhouse Emissions Information System

2023 assessment

While indicator 'E:01 Primary energy consumption' highlighted the substantial decline in primary energy consumption from 2010-11 to 2020-21, E:02 focuses on the specific energy sources.

The principal source of primary energy improvement is a decline in coal generation and its replacement with cleaner renewable generation (Table E4). There are also offsetting interannual oil and gas changes, presumably as a result of differing reporting dates of the data components.

Energy

Table E4: Primary energy consumption (PJ) in Victoria by fuel source from 2008-09 to 2020-21.[2047, 2048]

Financial Year	Coal	Oil	Gas	Renewables	Total	Total per person (GJ/person)
2010-11	681	489	266	45	1,456	263
2011-12	706	469	271	41	1,464	259
2012-13	622	488	280	55	1,429	248
2013-14	606	496	256	57	1,398	237
2014-15	641	465	260	59	1,394	232
2015-16	617	507	256	62	1,417	230
2016-17	577	512	262	66	1,388	220
2017-18	467	518	268	66	1,314	205
2018-19	444	507	260	72	1,279	196
2019-20	423	454	261	77	1,213	184
2020-21	428	389	241	88	1,136	174

The annual variation in primary energy consumption by fuel type is shown graphically in Figure E4, which clearly displays the significant year-on-year reductions in coal for most years during the past decade, and year-on-year increases in renewable sources of energy.

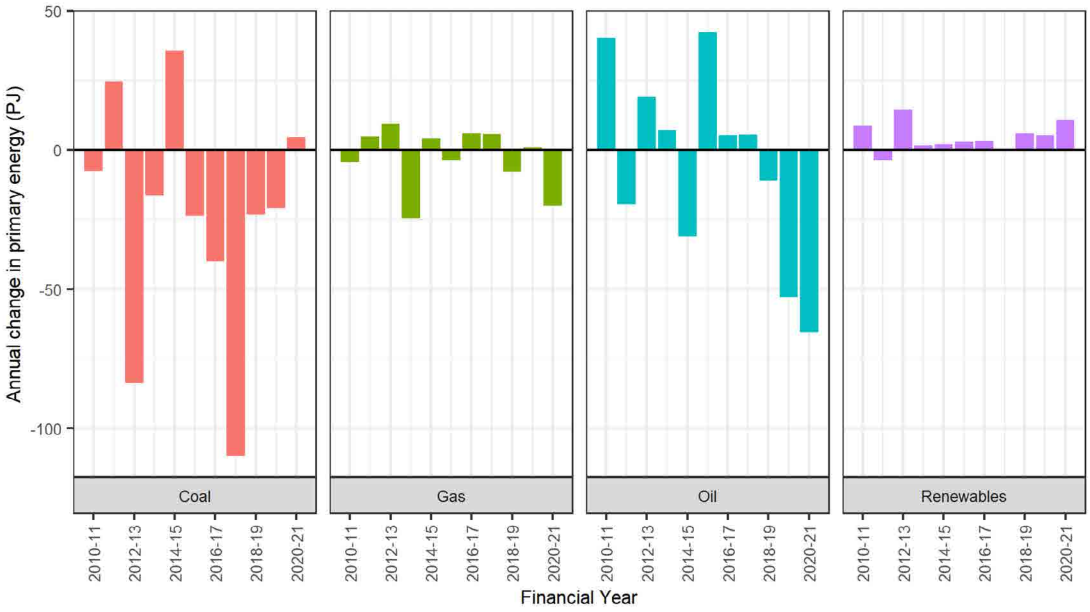


Figure E4: Annual changes in primary energy consumption (PJ) by fuel type in Victoria from 2010-11 to 2020-21.[2049]

2047. Department of Climate Change, Energy, the Environment and Water (DELWP) 2022, 'Australian energy statistics, Table C, September 2022', Canberra, Australia.
2048. Australian Bureau of Statistics (ABS), 'National, state and territory population', Reference period: March 2022, 3101.0 National state and territory population - TABLE 4. Estimated Resident Population, State and Territories (Number), Canberra, Australia, Accessed 24 November 2022.
2049. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table C, September 2022', Canberra, Australia.

Energy

In addition to the data on primary energy consumption by fuel source, Victoria's GHG emissions can be categorised by energy subsectors, and this shows electricity generation (50% of Victoria's net GHG emissions in 2020), transport (25%) and fuel (mainly gas) combustion (21%) are the three dominant energy subsectors in terms of the contribution to Victoria's net GHG emissions in 2020.[2050]

The positive story of reducing coal consumption and increasing renewable energy consumption is linked with electricity generation and GHG emissions from the state's electricity subsector — this is discussed further in indicator 'E:04 Electricity generation by fuel'. Oil and gas consumption are more aligned with the transport and fuel combustion subsectors — these subsectors are also discussed in more detail in subsequent indicators of this chapter.

While the increasing substitution of coal for renewables in electricity production is positive and reflected in a trend assessment of improving for this indicator, the electricity generation, transport and fuel combustion subsectors remain responsible for more than 95% of Victoria's net GHG emissions as of 2020. Because energy consumption from a range of fuels and subsectors comprises nearly all of Victoria's net GHG emissions, the status assessment for this indicator is fair, which is in line with the status assessment for indicator 'CC11: Annual greenhouse gas emissions'.

Power lines in rural Victoria.
Credit: BeyondImages.

[2050] Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Australian greenhouse emissions information system', Canberra, Australia, http://ageis.climatechange.gov.au Accessed 20 October 2022.

Energy

Indicator E:03 Electricity consumption

E:03 Electricity consumption						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🟢	↗	🟢	🟡	↗	🟢
Data source(s):	Australian Energy Market Operator, BP, DCCEEW					
Measure(s):	Electricity generation per capita GHG emissions from electricity generation as a percentage of Victoria's total net GHG emissions Per capita operational demand Electricity delivered on transmission networks per connection Electricity delivered on distribution networks per connection					

Why this indicator?

At a subsector level, the highest contributor to GHG emissions in Victoria in 2020 was the production of electricity, responsible for 50% of the state's net emissions (and 51% of the state's net energy sector emissions). This means that electricity generation and consumption is a critical area for Victoria to improve on the path to net zero GHG emissions by 2050.

NB: This SoE 2023 indicator was 'E:05 Total electricity consumption' in the SoE 2018 Report.

Why this assessment in 2023?

The status for this indicator has been assessed as good due to the substantial decline in electrical demand measured as throughput on distribution networks, transmission networks or operating demand, which will have resulted in a commensurate reduction in fossil fuel electricity production.

Summary of State of the Environment 2018 Report assessment

- Electricity consumption had been declining during the past five years despite population and economic growth. However, it remained well above 1989–90 levels.
- Overall efficiency of end use was noted to need to improve alongside growth in low-carbon generation for emissions reduction targets to be achieved.

Critical data used for the 2023 assessment

- Australian Energy Update 2022 (Table B and Table O)
- Australian Greenhouse Emissions Information System
- BP Statistical Review of World Energy 2022
- Australian Energy Market Operator data for operational demand
- Australian Energy Regulator for electricity delivered on transmission networks and electricity delivered on distribution networks

2023 assessment

Electricity consumption

Victoria's electricity consumption can be compared with G20 countries. If Victoria was a country, it would have recorded the greatest percentage decline in electricity generation per capita from 2011 to 2021. The reduction of 25% in Victoria substantially exceeds the 9% decline in Australia (Table E5). Over this period, Australia was ranked 17th out of the 19 G20 countries for electricity generation per capita at the start and end of the period — with the ranking based on the least electricity generated per capita. By comparison, Victoria would have improved from a ranking of 17th to 12th.[2051, 2052, 2053]

2051. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2052. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table O, September 2022', Canberra, Australia.
2053. British Petroleum (BP) 2022, 'BP statistical review of world energy 2022 | 71st edition', London, United Kingdom, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf Accessed 20 October 2022.

Table E5: Comparison of electricity generation per capita (MWh/person) among G20 countries and Victoria between 2011 and 2021.[2054, 2055, 2056]

G20 countries	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Percent change from 2011 to 2021
Canada	18.6	18.3	18.7	18.3	18.5	18.4	18.2	17.7	17.3	17.1	16.8	-10%
US	14.0	13.7	13.7	13.7	13.6	13.5	13.2	13.7	13.4	12.9	13.3	-5%
South Korea	10.4	10.6	10.7	10.6	10.7	11.0	11.2	11.5	11.3	11.1	11.6	12%
Australia	11.5	11.0	10.8	10.5	10.7	10.7	10.5	10.5	10.5	10.3	10.4	-9%
Saudi Arabia	8.8	9.3	9.5	10.1	10.7	10.4	10.7	9.9	9.8	9.7	10.1	14%
Japan	8.6	8.7	8.5	8.3	8.1	8.1	8.2	8.3	8.1	7.9	8.1	-6%
France	8.6	8.6	8.7	8.5	8.6	8.3	8.3	8.6	8.4	7.8	8.1	-6%
Russian Federation	7.4	7.5	7.4	7.4	7.4	7.6	7.6	7.7	7.7	7.5	8.1	9%
Victoria	10.4	9.9	9.4	9.4	9.4	9.0	8.3	7.6	7.4	7.7	7.8	-25%
Germany	7.6	7.8	7.9	7.7	7.9	7.9	7.9	7.7	7.3	6.9	7.0	-8%
China	3.5	3.7	4.0	4.2	4.2	4.4	4.7	5.1	5.3	5.5	6.0	72%
Italy	5.1	5.0	4.8	4.6	4.7	4.8	4.9	4.8	4.9	4.7	4.9	-5%
United Kingdom	5.8	5.7	5.6	5.2	5.2	5.2	5.1	5.0	4.8	4.7	4.6	-21%
South Africa	5.0	4.9	4.8	4.7	4.5	4.5	4.5	4.4	4.3	4.0	4.1	-19%
Turkey	3.1	3.2	3.2	3.3	3.3	3.4	3.7	3.7	3.6	3.6	3.9	25%
Argentina	3.1	3.3	3.3	3.2	3.4	3.4	3.3	3.3	3.1	3.2	3.3	6%
Brazil	2.7	2.8	2.8	2.9	2.8	2.8	2.8	2.9	3.0	2.9	3.1	14%
Mexico	2.5	2.5	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.5	2.6	2%
India	0.8	0.9	0.9	1.0	1.0	1.1	1.1	1.2	1.2	1.1	1.2	49%
Indonesia	0.7	0.8	0.9	0.9	0.9	0.9	1.0	1.1	1.1	1.1	1.1	50%

Note: The data for the G20 countries in this table was taken from BP's Statistical Review of World Energy (2022) and contained annual data. Victoria's data (taken from Australian Energy Statistics Table B and Table O published in 2022) is based on financial year data that has been averaged to derive annual values (e.g. the data for 2019-20 and 2020-21 have been averaged to calculate an annual Electricity generation per capita value for 2020). Also note that the 2021 value for Victoria is based on 2020-21 data.

GHG emissions from electricity generation

GHG emissions from electricity generation arise from the combustion of fuels to generate power supplied to the electricity grid. In 2020, emissions from fossil fuel fired-electricity generation accounted for 41.7 Mt CO_2-e, which was approximately half (50.1%) of Victoria's total net emissions.[2057] This result for 2020 represents a 36% reduction (23.6 Mt CO_2-e) in GHG emissions from electricity generation across the most recent decade (2010-2020).

2054. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2055. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table O, September 2022', Canberra, Australia.
2056. British Petroleum (BP) 2022, 'BP statistical review of world energy 2022 | 71st edition', London, United Kingdom, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf Accessed 20 October 2022.
2057. Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian greenhouse gas emissions report 2020', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0036/598257/Victorian-Greenhouse-Gas-Emissions-Report-2020.pdf Accessed 20 October 2022.

Victoria's *Climate Change Act* established a long-term target of net zero GHG emissions by 2050, and a requirement to set five-yearly interim emissions reduction targets.[2058] The Victorian Government set a foundational target for emissions to be 15% to 20% below 2005 levels by 2020, which has been achieved.[2059] The GHG emissions reduction associated with electricity generation was the primary reason this target was achieved.

Operational demand and electricity delivery

Figure E5 presents an index (beginning with a value of 1 in 2007) of operational demand per capita in the five regions of the NEM.[2060] It shows that operational demand per capita in Victoria declined almost 40% over the 13-year period, a decline almost matched in South Australia, but around twice as large as the decline in Tasmania and Queensland.

Many factors explain the large decline in Victoria including high population growth, deindustrialisation and consumption efficiency. The growth of distributed solar also explains part of the decline, but as discussed in indicator 'E:04 Electricity generation by fuel', it is not a big part of the decline.

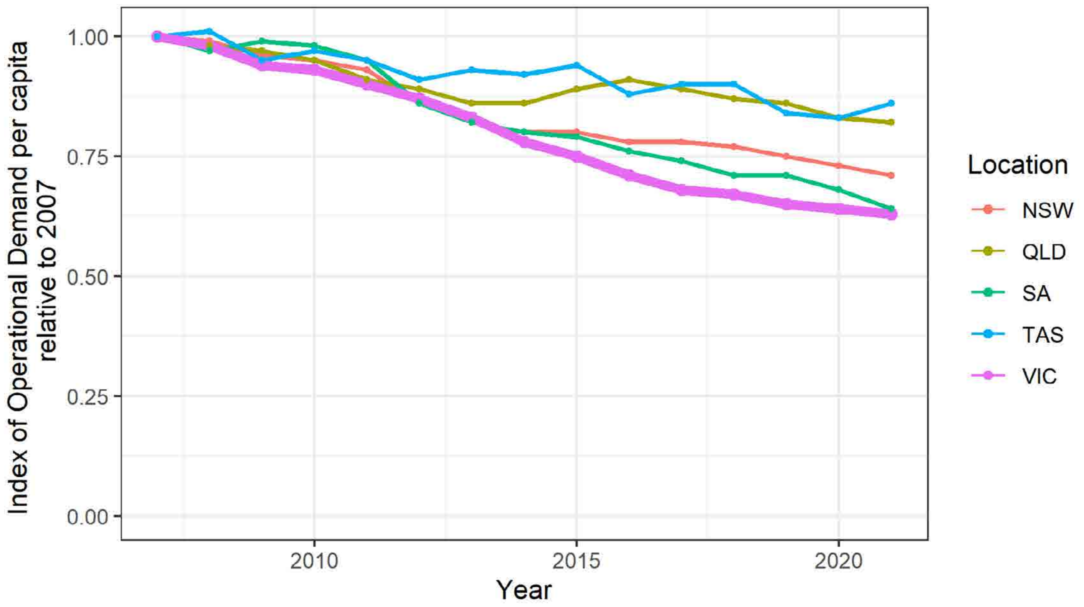


Figure E5: Per capita operational demand (index from 2007 to 2021) in Australian jurisdictions from 2010 to 2020.[2061, 2062]

Figure E6 shows the electricity delivered on transmission networks per connection in the five NEM regions. It shows a decline in all regions over this period and that Victoria consistently has the lowest volumes transported per connection. This reflects the role of gas in the Victorian economy, particularly in residential water heating and space heating — further analysis on gas is provided in indicator 'E:05 Gas consumption'.

[2058] State Government of Victoria 2022, '*Climate Change Act 2017*', Authorised Version No. 008 incorporating amendments as at 1 July 2022.

[2059] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian greenhouse gas emissions report 2020', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0036/598257/Victorian-Greenhouse-Gas-Emissions-Report-2020.pdf Accessed 20 October 2022.

[2060] Operational Demand in a region is defined by Australian Energy Market Operator (AEMO) as demand that is met by local scheduled generating units, semi-scheduled generating units, and non-scheduled intermittent generating units of aggregate capacity ≥30 MW, and by generation imports to the region and by Wholesale Demand Response.

[2061] Australian Energy Market Operator (AEMO), 'Market data NEMWEB', https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/market-data-nemweb.

[2062] Note that Australian Capital Territory is incorporated within the New South Wales region as part of the NEM.

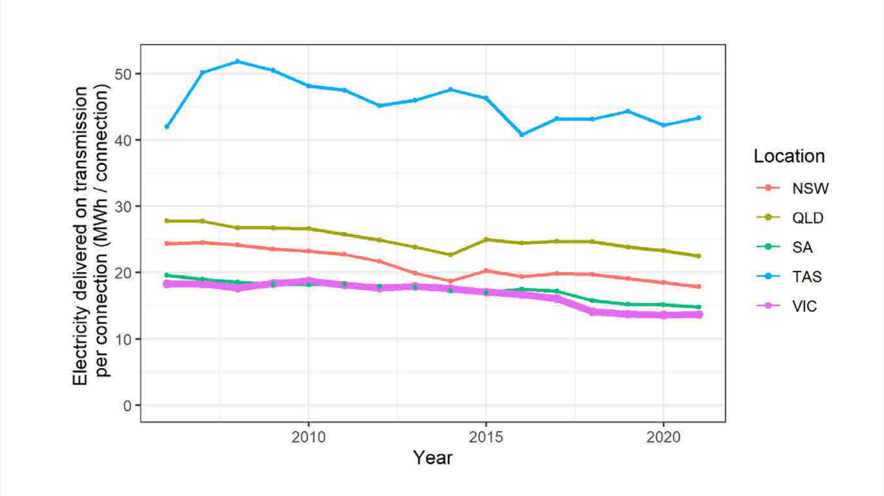


Figure E6: Electricity delivered on transmission networks per connection (MWh/connection) in Australian jurisdictions from 2006 to 2021.[2063, 2064]

Figure E7 shows the electricity delivered on distribution networks per connection from 2006 to 2021 in the five regions of the NEM. Again, the results are lower for Victoria than in other regions of the NEM, with a comparable decline over this period than in other states.[2065] The relative decline in electricity delivered on distribution networks is lower than the relative decline in operational demand due to the increase in rooftop solar. This is because the rooftop solar injected into electricity distribution networks is transported on distribution networks (and so counted in distribution network throughput), but rooftop solar is not counted in the measure of operational demand, which therefore deducts the full effect measured on transmission networks of distributed (behind the meter) electricity production.

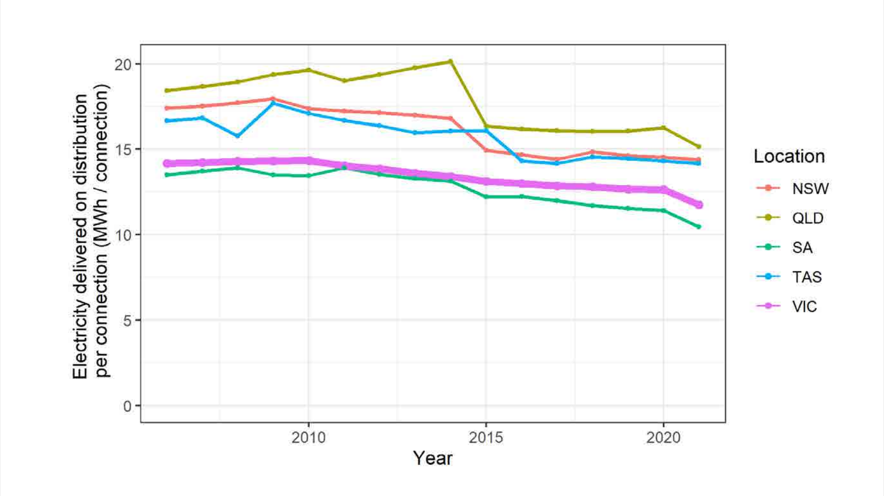


Figure E7: Electricity delivered on distribution networks per connection (MWh/connection) in Australian jurisdictions from 2006 to 2021.[2066, 2067]

[2063] Australian Energy Regulator 2022, 'Electricity TNSP operational performance data - 2006-2021', Canberra, Australia, https://www.aer.gov.au/system/files/Electricity%20TNSP%20Operational%20performance%20data%20-%202006-2021.xlsx Accessed 8 November 2022.

[2064] Note that the ACT is incorporated within the NSW region as part of the NEM.

[2065] The Queensland data appears to be impacted by changes in the definition of distribution and transmission, resulting in a step change increase in transmission values between 2014 and 2015 that is matched by a step change reduction in distribution network throughput.

[2066] Australian Energy Regulator 2022, 'Electricity DNSP operational performance data - 2006-2021', Canberra, Australia, https://www.aer.gov.au/system/files/Electricity%20DNSP%20Operational%20performance%20data%20-%202006-2021.xlsx Accessed 8 November 2022.

[2067] Note that the ACT is incorporated within the NSW region as part of the NEM.

Energy

Indicator E:04 Electricity generation by fuel

E:04 Electricity generation by fuel

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	↗	🟢	🔴	↗	🟢
Data source(s):	Australian Energy Market Operator, BP, DCCEEW					
Measure(s):	Generation of electricity, by fuel type Share of electricity generation, by fuel type Generation of electricity, by fuel type per capita Renewable electricity generation per capita Rooftop solar installation of percentage of dwellings in each region Rooftop solar electricity generation as percentage of Operating Demand in each NEM region					

Why this indicator?

The Victorian Government has legislated renewable energy targets (the proportion of electricity in Victoria to be produced from renewable sources) of 25% by 2020, 40% by 2025, and 50% by 2030.

This indicator helps track the progress of renewable energy as a share of electricity generation in Victoria, balanced against fossil fuels such as brown coal.

NB: This SoE 2023 indicator was 'E:06 Total electricity generation by fuel' in the SoE 2018 Report.

Why this assessment in 2023?

The dominance of coal for electricity generation in Victoria offsets the relatively high penetration of renewable sources when benchmarked against G20 countries. This is the basis of a status assessment of fair for this indicator.

Summary of State of the Environment 2018 Report assessment

- Generation from coal had decreased from a high of 90%. However, at 75% of electricity generated, coal remained the primary fuel source for electricity in Victoria.
- The proportion of energy generation from renewables was increasing. However, renewables accounted for less than 20% of total generation.

Critical data used for the 2023 assessment

- Australian Energy Update 2022 (Table B and Table O)
- BP Statistical Review of World Energy 2022
- Australian Energy Market Operator data for operational demand
- Clean Energy Regulator data for rooftop solar installations

2023 assessment

International and national comparisons

Figure E8 presents a panel of charts showing the electricity generation by fuel type (coal, gas, hydro and other renewables) and percentage shares comparing Australia and Victoria. It shows Victoria has experienced a similar progression to Australia, with a decreasing amount of electricity generated by coal and an increasing quantity generated by renewable sources.

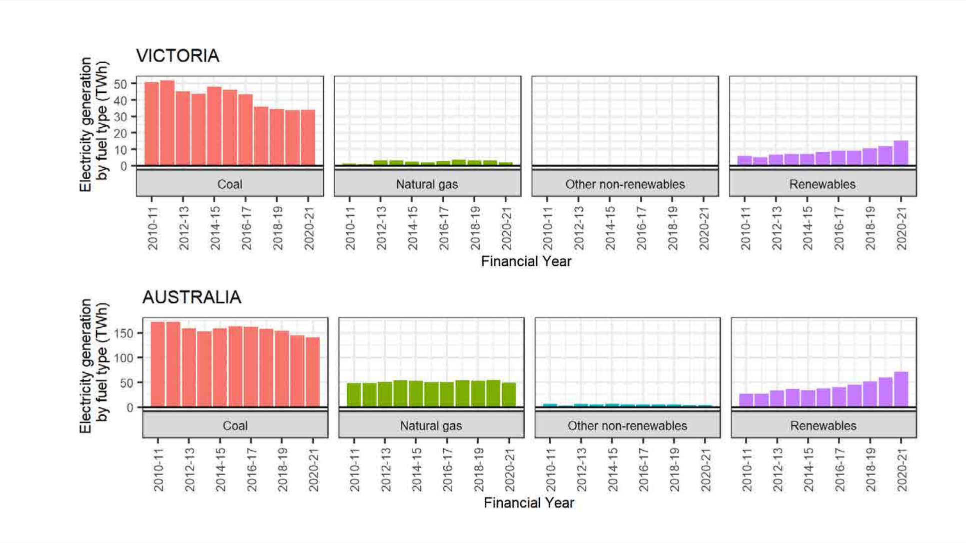


Figure E8: Generation of electricity (TWh) by fuel type in Victoria and Australia from 2010-11 to 2020-21.[2068]

Figure E9 shows the electricity generation for each fuel type as a percentage of total electricity generation. As of 2020-21, renewable sources have increased to be contributing 30% of Victoria's electricity generation (up from 6% in 2008-09), while coal has dropped to 66% (down from 92% in 2008-09). Australia's fuel mix for electricity generation is similar to Victoria's, with coal generating 53% and renewables 27% in 2020-21.[2069]

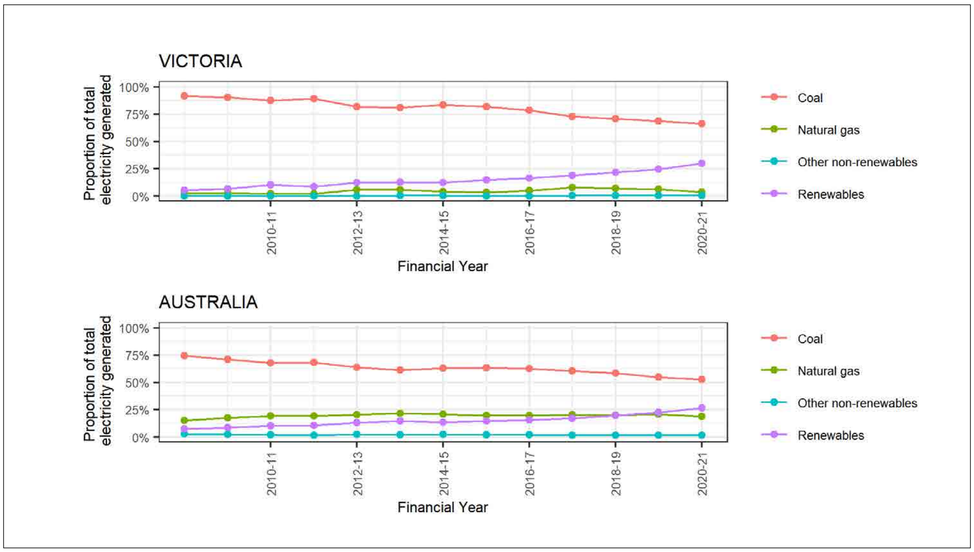


Figure E9: Share of electricity generation by fuel type in Victoria and Australia from 2008-09 to 2020-21.[2070]

2068. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table O, September 2022', Canberra, Australia.
2069. Ibid.
2070. Ibid.

Energy

Table E6 presents a breakdown of electricity generation by fuel type in Australia and Victoria compared to G20 countries. Australia's gas generation ranks in the middle of the pack compared to other G20 countries, while Victoria generates much less gas per person and only three G20 countries have a better (lower) reported value — only China, India and Indonesia use less gas per person in electricity generation than Victoria.[2071, 2072, 2073]

Australia and Victoria have by far the highest electricity generation per person from coal, although as a proportion of the energy mix, it is higher in South Africa and India, and approximately the same in Indonesia and China. Australia stands alone as the only rich country with such a large proportion of energy derived from coal, and Victoria is a significant contributor to Australia's electricity generation from coal. However, Australia (and Victoria) is also unusual in having close to the highest (non-hydro) renewable electricity generation per person (only Germany is higher) when measured in absolute terms, although relative to total energy consumed per capita, both the United Kingdom and Germany have significantly higher (non-hydro) renewable energy per capita.

Table E6: Comparison of electricity generation by fuel type per capita (MWh/person) among G20 countries and Victoria in 2021.[2074, 2075, 2076]

G20 countries	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renewables	Other
Argentina	0.17	2.04	0.06	0.24	0.43	0.38	0.01
Australia	0.18	1.85	5.34	0.00	0.62	2.38	0.01
Brazil	0.10	0.41	0.11	0.07	1.70	0.67	0.00
Canada	0.08	1.99	1.01	2.40	9.96	1.31	0.02
China	0.01	0.19	3.78	0.29	0.92	0.82	0.04
France	No data	No data	No data	No data	No data	No data	No data
Germany	0.06	1.07	1.96	0.83	0.23	2.62	0.27
India	0.00	0.05	0.91	0.03	0.12	0.12	0.00
Indonesia	0.02	0.20	0.69	0.00	0.09	0.11	0.00
Italy	0.14	2.48	0.25	0.00	0.73	1.21	0.06
Japan	0.25	2.59	2.40	0.49	0.62	1.04	0.73
Mexico	0.25	1.56	0.10	0.09	0.27	0.30	0.00
Russian Federation	0.06	3.46	1.43	1.55	1.50	0.04	0.03
Saudi Arabia	3.96	6.11	0.00	0.00	0.00	0.02	0.00
South Africa	0.03	0.00	3.49	0.17	0.02	0.28	0.08
South Korea	0.14	3.41	4.09	3.05	0.06	0.78	0.08
Turkey	0.00	1.30	1.23	0.00	0.65	0.74	0.00
United Kingdom	0.02	1.84	0.10	0.68	0.07	1.74	0.15
US	0.06	5.10	2.95	2.47	0.78	1.88	0.04
Victoria *	0.03	0.30	5.20	0.00	0.44	1.79	0.11

** The data for the G20 countries in this table was taken from BP's Statistical Review of World Energy (2022) and contained annual data. Victoria's data (taken from Australian Energy Statistics Table B and Table O published in 2022) is based on financial year data that has been averaged to derive annual values (e.g. the data for 2019-20 and 2020-21 have been averaged to calculate an annual Electricity generation per capita value for 2020). Also note that the 2021 value for Victoria is based on 2020-21 data.*

2071. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2072. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table O, September 2022', Canberra, Australia.
2073. British Petroleum (BP) 2022, 'BP statistical review of world energy 2022 | 71st edition', London, United Kingdom, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf Accessed 20 October 2022.
2074. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2075. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table O, September 2022', Canberra, Australia.
2076. British Petroleum (BP) 2022, 'BP statistical review of world energy 2022 | 71st edition', London, United Kingdom, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf Accessed 20 October 2022.

Energy

Victoria's changing electricity system

A significant reduction in GHG emissions from electricity in Victoria was presented in indicator 'E:03 Electricity consumption'. Underlying this decline is a transformation of the state's electricity system, with ageing brown coal-powered electricity generators gradually being decommissioned and replaced by renewable sources of energy.

Over the last decade, Morwell (2014), Anglesea (2015) and Hazelwood (2017) power stations have closed, with Yallourn scheduled for closure in 2028 and Loy Yang A in 2035. These changes have led to brown coal's contribution to Victoria's electricity generation falling from 87% in 2010-11 to 66% in 2020-21.[2077]

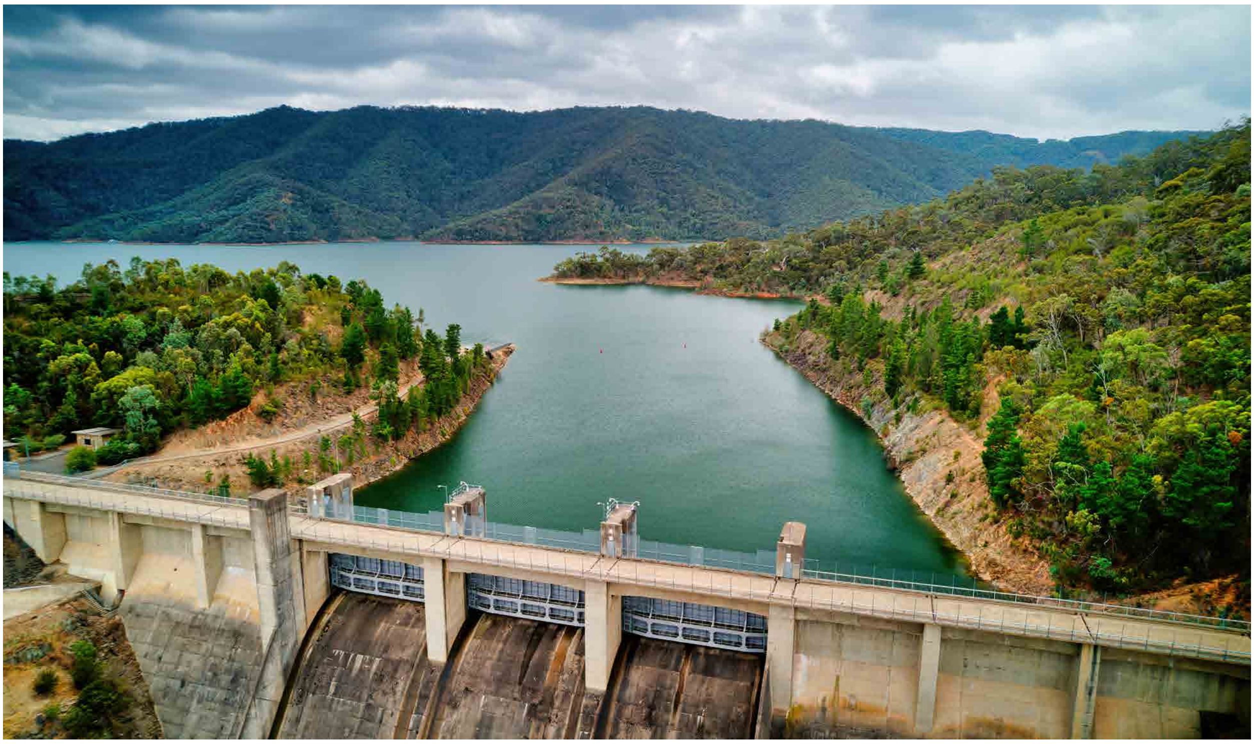
Simultaneously, the pace of renewable energy installation and use is accelerating, with renewables contributing 30% of electricity generated in Victoria in 2020-21, up by 20 percentage points in the past decade (from 10% in 2010-11 to 30% in 2020-21).[2078, 2079]

The Victorian Government has renewable energy targets of 25% by 2020, 40% by 2025 and 50% by 2030. The first of these targets has been met.[2080] As part of updated emissions reduction commitments made in 2022, the Victorian Government stated it will increase its 2030 target from 50% renewable electricity generation to 65%, and that it will set a new target of 95% renewable electricity generation by 2035.[2081]

Renewable electricity generation

Table E7 shows the mix of renewable electricity generation per capita in Victoria and Australia compared to G20 countries. In wind generation, Australia (and Victoria) is third behind the United States and Germany, although Canada and the United Kingdom also have comparable levels of wind generation per capita.

For solar, Australian per capita solar generation is far ahead other G20 countries. Victoria generates less solar per capita than Australia, but would rank ahead of all international G20 countries, just ahead of Japan.



Aerial view of the Lake Eildon hydroelectric infrastructure dam and surrounds.
Credit: Alistair McLellan.

[2077] Department of Environment, Land, Water and Planning (DELWP) 2022, 'Victorian greenhouse gas emissions report 2020', Melbourne, Victoria, https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0036/598257/Victorian-Greenhouse-Gas-Emissions-Report-2020.pdf Accessed 20 October 2022.

[2078] Ibid.

[2079] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table O, September 2022', Canberra, Australia.

[2080] Department of Environment, Land, Water and Planning (DELWP) 2021, 'Victorian renewable energy target 2020/21 progress report', Melbourne, Victoria.

[2081] Department of Energy, Environment and Climate Action (DEECA), 'Victorian renewable energy and storage targets', https://www.energy.vic.gov.au/renewable-energy/victorian-renewable-energy-and-storage-targets Accessed 15 February 2023.

Table E7: Comparison of renewable electricity generation per capita (MWh/person) among G20 countries and Victoria in 2021.[2082, 2083, 2084]

G20 countries	Wind	Solar	Other renewables[2085]	Total
Germany	1.42	0.59	0.61	2.62
Australia	1.04	1.21	0.13	2.38
Victoria *	1.09	0.71	0.55	2.35
US	1.16	0.50	0.23	1.88
United Kingdom	0.96	0.18	0.59	1.74
Canada	0.92	0.13	0.25	1.31
Italy	0.35	0.42	0.44	1.21
Japan	0.07	0.69	0.28	1.04
France	0.55	0.22	0.17	0.93
China	0.46	0.23	0.12	0.82
South Korea	0.06	0.42	0.29	0.78
Turkey	0.37	0.15	0.22	0.74
Brazil	0.34	0.08	0.26	0.67
Argentina	0.28	0.05	0.05	0.38
Mexico	0.16	0.09	0.05	0.30
South Africa	0.14	0.13	0.01	0.28
India	0.05	0.05	0.03	0.12
Indonesia	0.00	0.00	0.11	0.11
Russian Federation	0.02	0.02	0.00	0.04
Saudi Arabia	0.00	0.02	0.00	0.02

** The 2021 value for Victoria is based on 2020-21 data.*

Behind-the-meter renewable electricity generation

There are now many rooftop solar systems in Victoria which generate renewable electricity on-site at houses and businesses. Some of this electricity is consumed on-site and reduces mains electricity consumption, and the remainder is fed into the electricity grid and becomes part of the overall electricity supply.

Figure E10 examines rooftop solar installation as a percentage of dwellings in each state and territory of Australia at the end of 2021, while Figure E11 displays rooftop solar electricity generation as a percentage of the grid-supplied demand in the five states of the NEM in 2021. Figure E10 shows that Queensland and South Australia lead with 42% and 41% of households installed with rooftop solar, respectively. Victoria has the second lowest penetration (23%), just ahead of Tasmania (17%).

2082. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2083. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table O, September 2022', Canberra, Australia.
2084. British Petroleum (BP) 2022, 'BP statistical review of world energy 2022 | 71st edition', London, United Kingdom, https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2022-full-report.pdf Accessed 20 October 2022.
2085. Includes electricity generated from: geothermal, biomass and other sources of renewable energy not already itemised.

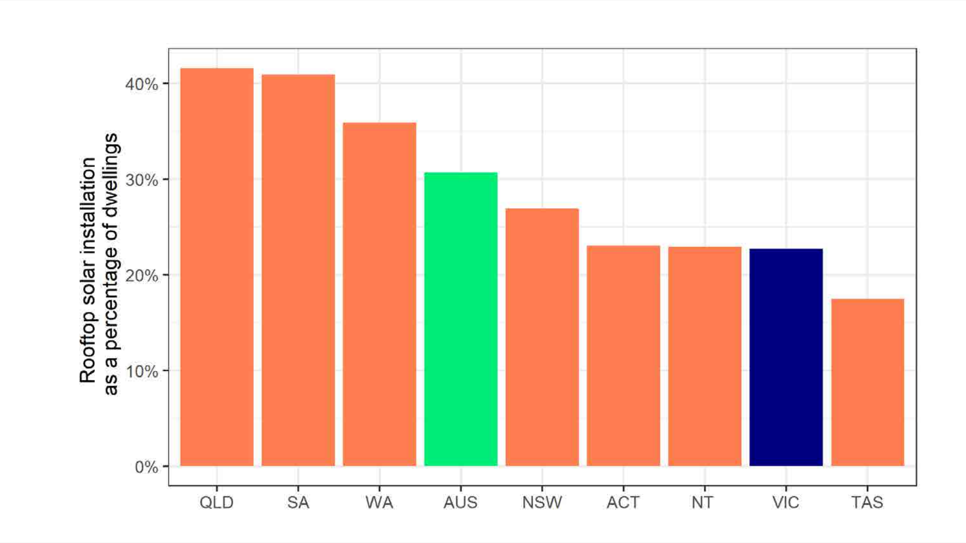


Figure E10: Percentage of dwellings having rooftop solar installations in each Australian jurisdiction at the end of 2021.[2086]

Figure E11 shows that, despite having comparable rooftop solar penetration, the production from rooftop solar in South Australia as a proportion of operational demand is almost twice that of Queensland. This generally reflects much lower operational demand in South Australia than Queensland. Victoria's rooftop solar production has roughly doubled as a percentage of operational demand from 2016 to 2021, but still lags the production in other states except Tasmania.

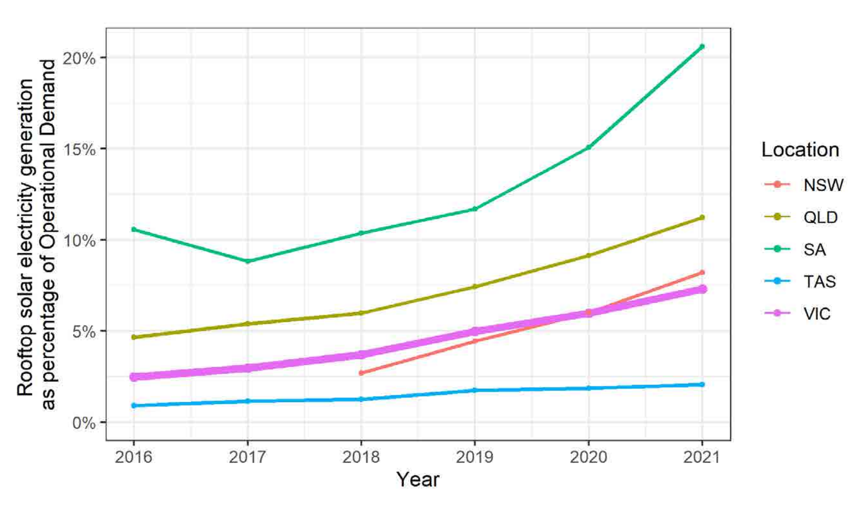


Figure E11: Rooftop solar electricity generation as a percentage of operational demand in each Australian NEM region from 2016 to 2021.[2087, 2088]

The dominance of coal for electricity generation in Victoria offsets the relatively high penetration of renewable sources when benchmarked against G20 countries. This is the basis of a status assessment of fair for this indicator.

[2086] Clean Energy Regulator 2022, 'Postcode data for small-scale installations', Canberra, Australia, https://www.cleanenergyregulator.gov.au/RET/Forms-and-resources/Postcode-data-for-small-scale-installations Accessed 8 November 2022.

[2087] Australian Energy Market Operator (AEMO), ''Market Data NEMWEB', https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/market-data-nemweb Accessed 8 November 2022.

[2088] Note that the Australian Capital Territory is incorporated within the New South Wales region as part of the NEM.

Indicator E:05 Gas consumption

E:05 Gas consumption						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🔴	→	🟢	New SoE 2023 indicator	New SoE 2023 indicator	New SoE 2023 indicator
Data source(s):	Australian Energy Market Operator, DCCEEW					
Measure(s):	Gas consumption Gas consumption per capita Gas distributed on distribution networks per capita					

Why this indicator?

More than two million Victorian homes and businesses use gas – more users than any other state or territory. Gas prices are rising steadily, GHG emissions from gas are a significant component of state emissions and international events are causing uncertainty in gas supply and price around the world. This means that reducing gas consumption and associated GHG emissions within Victoria's gas sector is an important and immediate focus area for the state.

NB: This is a new SoE 2023 indicator that was not included in the SoE 2018 Report. This indicator has been included to address a gap on gas consumption in previous state of the environment reports.

Why this assessment in 2023?

The status of this indicator has been assessed as poor taking into consideration the small decline in per capita gas consumption in Victoria (in comparison to electricity), an under-performance in Victoria relative to South Australia and New South Wales for gas distribution per customer, and international events causing uncertainty in gas supply and price around the world.

Summary of State of the Environment 2018 Report assessment

- New SoE 2023 indicator

Critical data used for the 2023 assessment

- Australian Energy Update 2022 (Table B and Table Q)
- Australian Energy Regulator data for gas distributed on distribution networks

2023 assessment

In Victoria, gas consumption was generally stable within the past decade until an 8% decrease from 2019-20 to 2020-21.[2089] This pattern has been driven by population and housing growth being balanced by gas appliances becoming slightly more efficient over time, while industry gas-use has been declining — this mix of factors has led to Victoria's overall state gas demand and GHG emissions remaining relatively constant. This needs to change significantly if Victoria is to meet its GHG emission targets. Table E8 displays the past 20 years of data on gas consumption in Australian states and territories, showing big growth in the Northern Territory, Queensland and Western Australia. This is predominantly explained by increasing gas consumption in the new liquified natural gas export industries. In New South Wales, South Australia and Tasmania, consumption grew and then declined over the period to the levels at the start of the period. In Victoria, gas consumption grew over the period to peak in 2008-09 and 2012-13 before returning to nearly the same value in 2020-21 as twenty years ago.

[2089] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table Q, September 2022', Canberra, Australia.

Table E8: Gas consumption (million cubic metres) in Australia and its states and territories from 2000-01 to 2020-21.[2090]

Financial Year	Australia	Western Australia	Queensland	Victoria	New South Wales	Northern Territory	South Australia	Tasmania
2000-01	24,317	8,141	2,296	6,358	3,811	541	3,170	-
2001-02	24,684	8,325	2,344	6,483	3,763	554	3,215	-
2002-03	24,701	7,903	2,512	6,680	3,749	354	3,384	119
2003-04	25,530	8,236	2,607	6,999	3,708	368	3,421	191
2004-05	26,090	8,806	2,604	6,989	3,587	386	3,487	231
2005-06	26,186	9,108	2,635	6,978	3,531	465	3,209	261
2006-07	29,563	10,028	4,428	6,992	3,314	856	3,647	297
2007-08	30,539	10,213	4,750	7,269	3,267	780	3,885	375
2008-09	32,653	11,871	5,018	7,373	3,515	998	3,578	298
2009-10	32,786	11,875	5,228	7,110	3,971	1,049	3,190	362
2010-11	33,197	12,375	5,088	6,993	3,913	1,103	3,253	472
2011-12	34,901	12,586	6,573	7,124	3,796	1,049	3,343	431
2012-13	35,799	12,887	6,404	7,373	4,202	1,132	3,328	473
2013-14	35,936	13,402	6,889	6,730	4,459	1,184	2,940	332
2014-15	36,530	13,497	7,875	6,836	4,365	1,124	2,657	176
2015-16	37,377	14,048	7,915	6,738	4,401	1,245	2,686	346
2016-17	38,352	14,876	8,267	6,894	3,836	1,203	2,926	352
2017-18	39,806	16,085	8,071	7,044	3,847	1,173	3,215	372
2018-19	40,447	16,708	7,851	6,842	3,718	2,153	2,892	283
2019-20	42,027	17,329	8,357	6,869	3,789	2,717	2,770	198
2020-21	40,458	16,790	8,369	6,343	3,640	2,652	2,470	196

The residential subcategory surpassed manufacturing as the major consumer of gas in Victoria in 2006. Residential gas consumption has grown in line with population and the associated fossil gas demand for water and space heating.

Figure E12 shows per capita gas consumption from 2000-01 to 2020-21 in the five regions of the NEM.

It shows a 27% reduction for Victoria, which is driven by population change rather than a change in gas consumption — Victorian gas consumption in 2020-21 was nearly identical (within 0.25%) with the consumption in 2000-01. The 27% per capita gas consumption reduction is less than the decline in electricity consumption per capita (measured using operational demand), which has been 37% across the past 15 years (from 2007 to 2021).

[2090] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table Q, September 2022', Canberra, Australia.

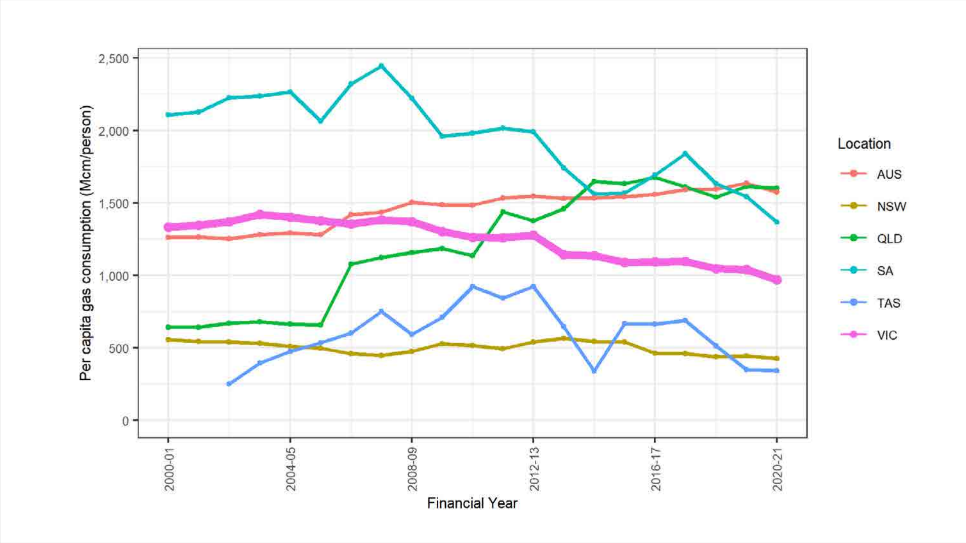


Figure E12: Gas consumption per capita (Mcm/person) in Australian jurisdictions from 2000-01 to 2020-21.[2091, 2092]

Figure E13 shows the volume of gas sold on distribution networks per customer in the three states where gas is used in some homes. The data from 2011-2020 shows a much bigger decline in New South Wales (-34%) than in Victoria (-15%).

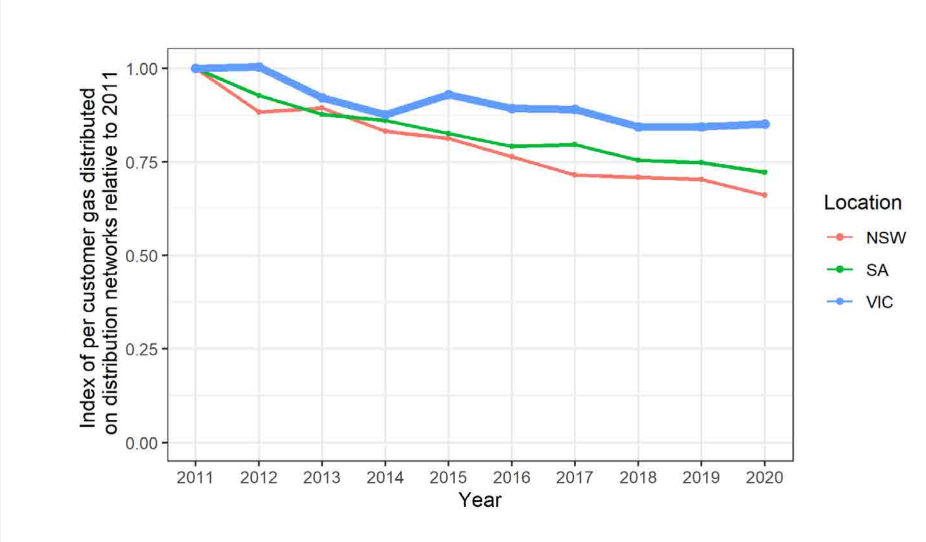


Figure E13: Gas distributed on distribution networks per customer (GJ/person) in New South Wales, South Australia and Victoria from 2011 to 2020.[2093]

Considering the small gas consumption decline per customer in Victoria (in comparison to electricity) and an under-performance in Victoria relative to South Australia and New South Wales for gas distribution per customer, the status for this indicator has been assessed as poor.

2091. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2092. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table Q, September 2022', Canberra, Australia.
2093. Australian Energy Regulator 2021, 'Gas distribution NSPs - Operational performance data - 2011-2020', Canberra, Australia, https://www.aer.gov.au/system/files/Gas%20Distribution%20NSPs%20-%20Operational%20performance%20data%20-%202011-2020.xlsb Accessed 8 November 2022.

Indicator E:06 Energy in transport

E:06 Energy in transport

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴	↗	🟢	🔴	↙	🟢

Data source(s):	DCCEEW
Measure(s):	Energy used in transport GHG emissions from transport

Why this indicator?

At a subsector level, the second-highest contributor to GHG emissions in Victoria in 2020 was transport, responsible for 25% of the state's net emissions. This means that transport energy consumption is an important area for Victoria to improve on the path to net zero GHG emissions by 2050.

NB: This SoE 2023 indicator was 'E:08 Energy used in the transport sector' in the SoE 2018 Report.

Why this assessment in 2023?

Victoria's performance in energy consumption (and GHG emissions) in transport is poor compared with GHG emissions in stationary energy.

The trend has been assessed as improving because energy use and GHG emissions from the transport subsector are both less than in the previous state of the environment reporting period, and the assessment must reflect observed measurements. However, this assessment for trend is almost certainly due to a reduction in travel associated with COVID-19 restrictions and is highly likely to be only temporary.

It is expected that transport energy usage and GHG emissions will increase back to near pre-pandemic levels during the next state of the environment reporting period.

Summary of State of the Environment 2018 Report assessment

- Transport energy use had increased by over 40% between 1989-90 and 2015-16.
- Transport energy use per capita had remained stable over the period despite population growth.

Critical data used for the 2023 assessment

- Australian Energy Update 2022 (Table B and Table F)
- Australian Greenhouse Emission Information System

2023 assessment

Figure E14 shows the total energy used in transport in Victoria over the period from 1973-74 to 2020-21. Over this period, liquified petroleum gas grew from 0.3 PJ to 32.4 PJ per annum but has since declined to 5.9 PJ per annum. Petrol use had remained roughly constant from the 1980s until a 21% drop from 2018-19 to 2020-21, but diesel has grown approximately six-fold from 21.5 PJ per annum in 1973-74 to 133.1 PJ in 2020-21 (and diesel only dropped by 5% from 2018-19 to 2020-21 compared to the 21% drop for petrol). Biofuel and electricity use in transport remain tiny and 'other', which is mainly dominated by aviation fuels, roughly doubled.[2094] The big reduction in 'other' in 2020-21 reflects the decline of air travel during the period of COVID-19 restrictions.

[2094] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table F, September 2022', Canberra, Australia.

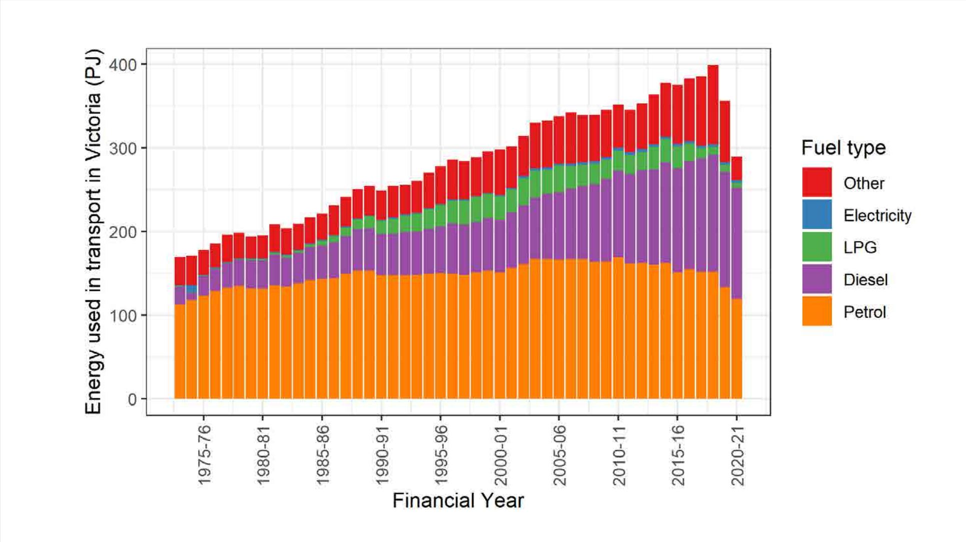


Figure E14: Energy used in transport (PJ) in Victoria from 1975-76 to 2020-21.[2095]

Figure E15 shows Victoria's GHG emissions from transport. The dip in the total during 2020 is likely to reflect restrictions in Victoria that formed part of the Victorian Government's response to the significant health risks posed by COVID-19. Between 1990 and 2019, total transport emissions increased by 43%, reflecting growth in emissions mainly from cars and light commercial vehicles (e.g. utes).[2096]

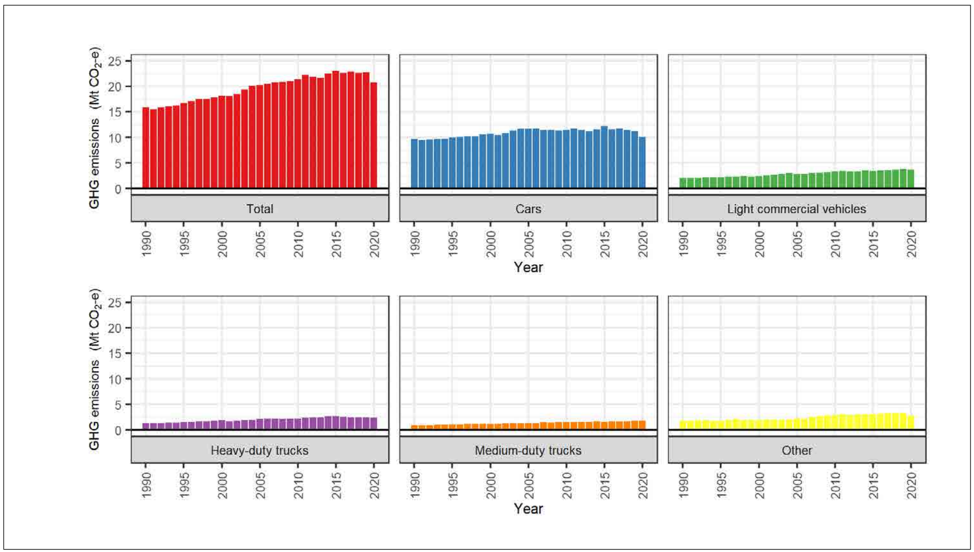


Figure E15: Greenhouse gas emissions from transport (Mt CO2-e) in Victoria from 1990 to 2020.[2097]

[2095] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table F, September 2022', Canberra, Australia.

[2096] Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Australian greenhouse emissions information system', Canberra, Australia, http://ageis.climatechange.gov.au Accessed 20 October 2022.

[2097] Ibid.

To reduce GHG emissions from the transport subsector, a combination of two changes is required:

- fossil fuel energy use per person needs to decline at a faster rate than population growth
- technological advancements must reduce GHG emission from transport.

Unlike total energy consumption per capita from all sectors, which has declined year-on-year in Victoria since 2009 (except for a minor increase in 2018), energy consumption from the transport subsector has not decoupled from population growth. Prior to the influence of COVID-19 on transport patterns, energy consumption from transport in Victoria increased by 61% from 1990-91 to 2018-19 compared to a population increase of 48% over the same period (June 1991 and June 2019).[2098] Figure E16 shows annual per capita energy use from transport in Victoria over time, which confirms that transport energy consumption per capita in 2018 was higher than 1990 but also shows it had been gradually declining since a peak of 66.8 GJ/person in 2004, indicating a slightly improving efficiency since then.[2099, 2100, 2101] From 2018-19 to 2020-21, transport energy use has dropped 27%, although this is likely to be substantially explained by COVID-19 restrictions. Without policy change, it is expected that transport energy usage will increase back to pre-pandemic levels during the next state of the environment reporting period.

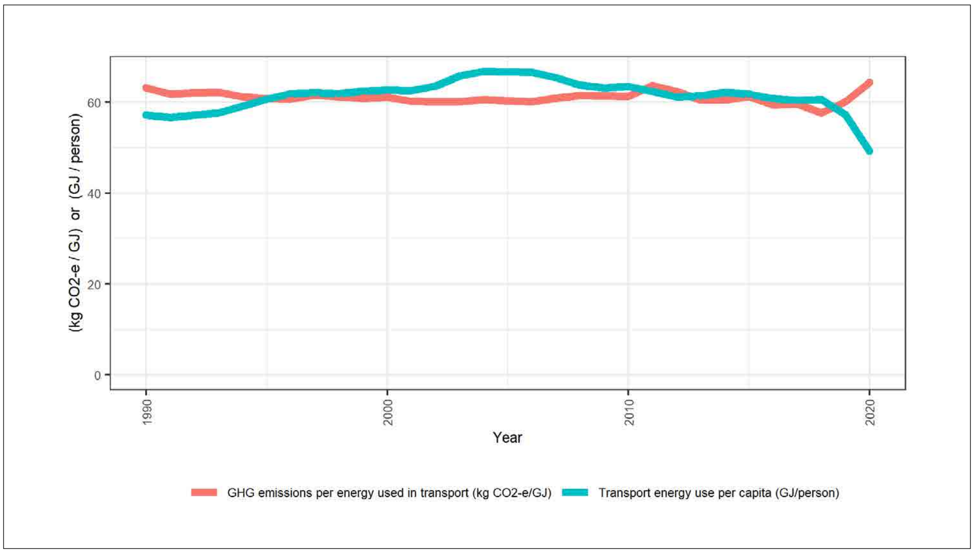


Figure E16: GHG emissions per energy used in transport (kg CO2-e/GJ) and transport energy use per capita (GJ/person) in Victoria from 1990 to 2020.[2102, 2103, 2104, 2105]

2098. Australian Bureau of Statistics (ABS), 'National, state and territory population', Reference period: March 2022, 3101.0 National state and territory population - TABLE 4. Estimated Resident Population, State and Territories (Number), Canberra, Australia, Accessed 24 November 2022.
2099. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2100. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table F, September 2022', Canberra, Australia.
2101. Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Australian greenhouse emissions information system', Canberra, Australia, http://ageis.climatechange.gov.au Accessed 20 October 2022.
2102. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
2103. Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table F, September 2022', Canberra, Australia.
2104. Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Australian greenhouse emissions information system', Canberra, Australia, http://ageis.climatechange.gov.au Accessed 20 October 2022.
2105. Note that the fuel consumption data are based on financial year data that has been averaged to derive annual values (e.g. the data for 2019-20 and 2020-21 have been averaged to calculate an annual transport energy consumption value for 2020).

Figure E16 also shows annual GHG emissions from the transport subsector as a ratio of transport energy usage. This provides a measure of the GHG efficiency of the transport subsector. The results show almost no change in GHG efficiency from 1990 to 2011, when between 60.1 and 63.7 kg CO_2-e were emitted per GJ of energy used. From 2011 to 2018, the GHG efficiency of the transport subsector had improved by 9%, but has since regressed and, as at the most recently available GHG emission data for this report (that is, 2020), is at its worst level since 1990.[2106, 2107, 2108] The deterioration during the past two years is likely associated with changed travel behaviour due to COVID-19 and a decrease in the usage of motor cars relative to trucks.

Victoria's performance in energy consumption (and GHG emissions) in transport during the past decade has been poor by comparison to GHG emissions in stationary energy, with only a 3% reduction in GHG emissions from the state's transport sector over the past decade (that is, form 2010-2020) compared to a 36% reduction in GHG emissions from electricity generation during the same period. Meaningful jurisdictional comparisons of transport fuel consumption and GHG emissions require adjustment for many factors, most notably population density and access to public transport. Such comparisons do not exist, although it is still relevant to note that Victoria ranked third in 2020 among Australian states and territories in terms of GHG emissions from transport per person (Australian Capital Territory and Tasmania ranked first and second, respectively). The average GHG emission intensity of new cars and light commercial vehicles sold in Australia in 2019 (the last year that the National Transmission Commission reports such data for) was 180.5 grams CO_2 per kilometre (g CO_2/km).[2109] By comparison, in the European Union, the comparable average was 122.3 g CO_2/km, which has since dropped to 107.5 g CO_2/km in 2020.[2110] Publicly available data in this sector, either nationally or for Victoria, is poor.

Petrol pumps hoses on a petrol station in Victoria - 98, 95, E10, 91, diesel.
Credit: Daria Nipot.

[2106] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table B, September 2022', Canberra, Australia.
[2107] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2022, 'Australian energy statistics, Table F, September 2022', Canberra, Australia.
[2108] Department of Climate Change, Energy, the Environment and Water (DCCEEW), 'Australian greenhouse emissions information system', Canberra, Australia, http://ageis.climatechange.gov.au Accessed 20 October 2022.
[2109] National Transport Commission 2020, 'Carbon dioxide emissions intensity for new Australian light vehicles 2019', Melbourne, Victoria, https://www.ntc.gov.au/sites/default/files/assets/files/Carbon-dioxide-emissions-intensity-for-new-Australian-light-vehicles-2019.pdf Accessed 8 November 2022.
[2110] European Environment Agency 2022, 'CO_2 performance of new passenger cars in Europe', Copenhagen, Denmark, https://www.eea.europa.eu/ims/co2-performance-of-new-passenger Accessed 8 November 2022.

Commissioner
for Environmental
Sustainability
Victoria

Waste and resource recovery (W)

Victorian State of the Environment 2023 Report

Caption: Overflowing public rubbish bin in Melbourne.
Credit: TkKurikawa.

Key findings

Waste persists as a significant issue in Victoria. The waste and resource recovery indicators in this State of the Environment (SoE) 2023 Report showed few demonstrable improvements since the SoE 2018 Report, with most indicators (five out of six) either declining in status and/or trend or maintaining an assessment of poor (Table W1).

Contributing to the deterioration or lack of progress were external factors that severely impacted Victoria's waste and resource recovery sector between 2018 and 2021 (i.e. during the SoE 2023 reporting period), particularly within the municipal solid waste (MSW) sector.

In January 2018, China began to stringently enforce restrictions on the importation of recycled materials under its National Sword policy. This impacted the global market for recyclable material as it effectively removed a key international market, which Victoria and Australia had relied upon heavily for trading sorted recyclables. This has created volatility in global and domestic pricing for recovered materials.

With limited export destinations available, the vulnerabilities within Victoria's waste and resource recovery sector were exposed. Local reprocessing capacity and capability were shown to be inadequate to manage the state's volume of recyclable material or the rapid concentration of waste generated by the MSW sector. The situation was exacerbated by the impact of the COVID-19 stay-at-home restrictions and the lack of local demand for recovered materials. Sharp increases in contamination levels among household recyclable materials have also lowered their value and potential for recovery.[2111]

With market influences being considered a major driver for legitimate stockpiling practices, excessive stockpiling of combustible waste materials ensued as waste recycling and recovery operators sought to redirect collected recyclables to alternative destinations and take advantage of economies of scale.[2112] What eventuated were a number of illegal incidents among resource recovery facilities, and their ultimate closure.[2113] With the loss of these facilities, significant quantities of household recyclables were landfilled during 2019 and 2020 and costs to local governments for managing waste rose.

Total waste generation (W:01) has been on an upward trajectory from 2014–15 to 2019–20, following a short period of decline from 2012–13 to 2013-14. By 2019–20, Victoria had discarded more waste than in any other financial year. The pattern of waste generation since 2014–15 followed a linear model, in that growth in waste levels trended in line with increases in the state's population and gross state product (GSP), with the rate of increase in waste generation surpassing that of population growth.[2114, 2115] During the SoE 2023 reporting period the amount of waste produced rose at a more rapid rate (10%) and peaked at a higher level (15.9 Mt) than during the SoE 2018 reporting period — 7% and 12.9 Mt, respectively.[2116] The escalating levels of waste generation in recent years is likely a reflection of higher levels of infrastructure development and improvements occurring within the state (e.g. the Big Build program of works).[2117]

Even after removing the effects of population growth, the pattern of rising waste generation in the state persists. There has been a gradual, but continued, upward trend in per-capita waste generation (W:02) — up from 1,188 kg in 2017–18 to 1,225 kg in 2019–20 — while resource recovery declined modestly overall (1%) across the three years that data were available, despite recyclables maintaining a larger proportion of per-capita waste totals. These findings suggest that factors other than population size are driving Victorians to dispose of progressively more waste and recycle less overall. This pattern was underpinned by

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2111. Envisage Works, IndustryEdge and Sustainable Resource Use (SRU) 2021, 'Victorian Market Intelligence Project', *Recovered Resources Market Bulletin*, e18, https://assets.sustainability.vic.gov.au/susvic/Recovered-Resources-Market-Bulletin-July-2021.pdf Accessed 12 August 2022.
2112. Infrastructure Victoria (IV) 2020, 'Advice on recycling and resource recovery infrastructure', Melbourne, Victoria https://www.infrastructurevictoria.com.au/wp-content/uploads/2020/03/Advice-on-recycling-and-resource-recovery-FINAL-REPORT.pdf Accessed on 29 July 2022.
2113. Environment Protection Authority (EPA) Victoria 2021, 'Management and storage of combustible recyclable and waste material', https://www.epa.vic.gov.au/about-epa/publications/1667-3 Accessed 8 June 2023.
2114. Van Fan Y, Klemeš JJ, Lee CT, Tan RR 2021, 'Demographic and socio-economic factors including sustainability related indexes in waste generation and recovery', *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, https://www.tandfonline.com/doi/full/10.1080/15567036.2021.1974610 Accessed 9 June 2023.
2115. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria – recycling industry workbook 2019-20', https://assets.sustainability.vic.gov.au/susvic/Workbook-Waste-Recycling-Industry-Workbook-2019%E2%80%9320.xlsx Accessed 5 July 2022.
2116. Data for the indicator assessments of this chapter does not cover the full SoE 2023 reporting period. Limitations in data availability have resulted in only a subset of years within the reporting cycle to be considered in the assessments. The range of years varies across the waste and resource recovery indicators.
2117. Blue Environment 2020, 'National waste report 2020', report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-report-2020.pdf Accessed 4 July 2022.

such factors as per-capita behaviour, the availability of adequate recycling collection services, particularly among the commercial and industrial (C&I) waste sector, as well as the clearance of stockpiled recyclables. Importantly, as the definition of per-capita behaviour in this report has been broadened to include waste generated from both the MSW and C&I sectors — not just the MSW as in previous state of the environment reports — direct comparisons across state of the environment reports are not possible.[2118]

The rate at which Victoria was diverting waste from landfill (W:04) had remained relatively stable since 2010-11, ranging from 63% to 70%, with the rate of increase slowing in more recent years (2017–18 to 2019–20). A modest increase of 5% was also observed across state of the environment reporting periods which is in contrast to the growth seen in both waste generation (32%) and disposal (20%) since 2012–13, meaning that Victorians are disposing of more waste every year.

During the SoE 2023 reporting period, the construction and demolition (C&D) sector had the highest diversion rate among all source sectors, recovering between 84% and 87% of generated waste. Increasing reliance on recycled materials for infrastructure projects contributed to much of the growth in material recovery by the C&D sector. This construction practice was standardised in 2020 under the Recycled First Policy, which mandates organisations delivering major transport projects to prioritise the use of recycled and reused materials over virgin materials.[2119] By contrast, the C&I and MSW sectors had considerably lower rates of waste diversion and present the greatest opportunity for improving resource recovery.

Food waste generation (W:03) has fluctuated across the state of the environment reporting periods. Following an overall decline from 2013–14 (1.2 Mt) to 2018–19 (1.1 Mt) and a 5% decrease in food waste generation in the SoE 2018 reporting period, food waste has begun to increase in recent years, with households being by far the greatest contributor to the state's food waste totals (70%). Given the declining rates of recovery, coupled with increasing levels of disposal during the SoE 2023 reporting period, food waste continued to represent a dominant waste stream entering landfill. This was particularly evident during 2018–19, when 16% of the state's total disposed waste was made up of food material, which equates to 711 Kt of food entering landfill.

The amount of litter (W:05) has been declining overall since the SoE 2018 Report, but there has been a small increase in recent years. Despite continued reductions in total annual litter items, the proportion of litter streams has remained relatively unchanged.[2120] Cigarette butts were consistently the largest litter type across years, while illegal dumping, plastic bags and other glass litter types contributed the least. Illegal dumping rates have been on the rise since the SoE 2018 Report, with peak dumping volumes occurring in 2018–19.[2121]

Hazardous waste (W:06) has been increasing, with Victoria reaching its highest levels of hazardous waste arisings by 2019–20, the second highest level in Australian jurisdictions.[2122, 2123] The level of growth was 24% in the SoE 2023 reporting period compared with 5% during the previous reporting cycle. Much of this recent growth has been driven by more asbestos, waste oil/water and contaminated soils being generated and managed.

As of 2019–20, large-scale development projects resulted in the unprecedented growth of contaminated soils, to become the largest single contributor (59%) of hazardous waste arisings in Victoria. During this same year there was a sharp rise in clinical waste arisings – personal protective equipment from the healthcare and aged care sectors, and to a smaller degree from communities – due to the COVID-19 pandemic. More interstate movement of hazardous waste was required to cope with the influx of personal protective equipment.

2118. This measurement change was made by CES, in consultation with data custodians, to align with the circular economy policy target, thereby improving future monitoring of progress towards the 15% reduction in per capita waste target.
2119. Ecologiq 2020, 'Recycled first policy', https://bigbuild.vic.gov.au/about/ecologiq/recycled-first-policy Accessed 9 June 2023.
2120. Keep Australia Beautiful (KAB) 2019, 'National litter index 2018-2019: Victoria results', Newtown, New South Wales https://assets.sustainability.vic.gov.au/susvic/Report-National-Litter-Index-2018-19-Victoria-results.pdf Accessed 14 July 2022.
2121. Sustainability Victoria (SV) 2020, 'Victorian local government annual waste services report 2018-19', Melbourne, Victoria https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Local-Government-Annual-Waste-Services-Report-2018-19.pdf Accessed 30 June 2022.
2122. The term 'arisings' is used in relation to hazardous waste data derived from tracking systems. Waste arises when it is delivered to hazardous waste processing, storage, treatment, or disposal infrastructure. This is distinguished from 'generation', a term commonly used in waste reporting. If hazardous waste is transported to more than one site, it may 'arise' more than once in the tracking system data.
2123. Blue Environment, Ascend Waste and Environment 2021, 'Australian hazardous waste data compilation (data up to and including financial year 2019–20)', report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW) https://www.dcceew.gov.au/sites/default/files/documents/national-hazwaste-data-collation-2019-20.xlsx Accessed on 5 July 2022.

Waste and resource recovery

Issues in the accuracy, breadth, and methodology of annual waste data collection and reporting have prevented a full understanding of waste generation and recovery patterns in Victoria , and they impede on the evaluation of progress towards the state's circular economy targets. These issues were highlighted by several inquiries and audits of Victoria's waste and resource recovery sector and led to mandated changes under the new legislative framework to modernise the state's waste data collection systems.[2124, 2125, 2126, 2127] The intended long-term gains arising from these actions have not yet been fully realised, and information gaps still remain in annual waste reporting. Therefore, data confidence for several waste and resource recovery indicators reported has been reduced.

Yarra River Pollution near Webb Bridge, Melbourne Australia.
Credit: FiledIMAGE.

[2124] Parliament of Victoria Legislative Council Environment and Planning Committee, 2019, 'Inquiry into recycling and waste management', https://www.parliament.vic.gov.au/file_uploads/LCEPC_59-02_Inquiry_into_recycling_and_waste_management__6hNrvBj7.pdf Accessed 28 July 2022.

[2125] Victorian Auditor-General's Office (VAGO) 2019, 'Recovering and reprocessing resources from waste: Independent assurance report to Parliament', Melbourne, Victoria, https://search.informit.org/doi/10.3316/agispt.20200107022396 Accessed 9 June 2023.

[2126] Infrastructure Victoria (IV) 2020, 'Advice on recycling and resource recovery infrastructure in Victoria', https://www.infrastructurevictoria.com.au/project/advice-on-waste-infrastructure-in-victoria Accessed 29 July 2022.

[2127] Victorian Auditor-General's Office (VAGO) 2021, 'Council waste management services', https://www.audit.vic.gov.au/report/council-waste-management-services?section= Accessed 28 July 2022.

Table W1: Waste and resource recovery indicators assessed in this chapter with comparisons to SoE 2018 assessments.

Waste and resource recovery							
2023 Indicator	**2023 status**	**2023 trend**	**2023 confidence**	**2018 Indicator**	**2018 status**	**2018 trend**	**2018 data quality**
Waste							
W:01 Total waste generation	🔴	↙	🟡	W:01 Total waste generation	🟡	→	🟢
W:02 Generation of waste per capita	🟡	?	🔴	W:02 Generation of waste per capita	🟡	→	🟢
Food waste							
W:03 Total food waste generation	🔴	?	🔴	W:03 Total food waste generated	🔴	→	🟢
Waste recycling							
W:04 Diversion rate	🔴	→	🔴	W:04 Diversion rate	🟡	→	🟢
Litter waste							
W:05 Litter and illegal dumping	🟡	→	🔴	W:05 Litter and illegal dumping	🟢	↗	🔴
Hazardous waste							
W:06 Total hazardous waste managed	🔴	↙	🟡	W:06 Total hazardous waste managed	🟡	→	🟡

Victorian Government progress on State of the Environment 2018 Report recommendations

The SoE 2018 Report included recommendations to the Victorian Government to improve environmental sustainability outcomes. Presented below are the recommendations specific to this theme as well as:

- the full government response to the recommendations, including the level of support, as published in the Victorian Government Response to the State of the Environment 2018 Report
- a description of progress made on the implementation of the recommendation over the past five years. The content of this section is derived from written material supplied directly to the Commissioner for Environmental Sustainability by relevant government entities and/or it synthesises information that is publicly available in referenced reports, legislation and websites. Importantly, this section summarises the progress made since 2018 in relation to the recommendation; it is not an audit of the extent and quality of the completed work.

Recommendation 13 of the SoE 201 Report recommended:

> *That Sustainability Victoria, in 2019, develop indicators and implement a comprehensive monitoring and reporting framework to measure delivery of the current Victorian Statewide Waste and Resource Recovery Infrastructure Plan (SWRRIP) and the regional plans against the circular-economy design principles. From July 2020, that Sustainability Victoria expand that monitoring and reporting framework to track the progress of the implementation of the strategy and publicly report, at least annually, on Victoria's transition to a circular economy.*

Government response in 2020:

SUPPORT IN PRINCIPLE

> 'The Victorian Government supports the intent of this recommendation.' [2128]
>
> 'The Government recognises the need to measure, monitor and report on Victoria's transition to a circular economy and that circular economy planning and policy decisions need to be informed by reliable data. Monitoring the transition will require a range of indicators, including some for which data are already being capture and others that will require more work to undertake baseline analyses and establish data collection and reporting processes. In line with policy priorities and its new Recycling Victoria: A New Economy policy the Government will explore options for how to achieve this outcome.' [2129]
>
> 'The focus of the SWRRIP and regional infrastructure plans is ensuring there is appropriate infrastructure in place to manage the changing volumes and types of materials entering Victoria's waste and resource recovery system in the coming years. The Government will ensure circular economy principles are reflected in future amendments to these plans, which will continue to be monitored and evaluated.' [2130]

Progress made since 2018

Since 2018, Sustainability Victoria (SV) has undertaken regular engagement with waste and resource recovery hubs, local governments and waste and resource recovery operators. This engagement had SV provide advice about the SWRRIP and how to better achieve circular economy outcomes, and also seek input from these audiences to inform future work and advice. As required by the earlier Environment Protection Act 2017, a detailed economic and transport analysis of the SWRRIP was also prepared and the findings of this went into the 2018 SWRRIP.

The Victorian Recycling Infrastructure Plan will eventually replace the SWRRIP.

2128. Victorian Auditor-General's Office (VAGO) 2021, 'Council waste management services', https://www.audit.vic.gov.au/report/council-waste-management-services?section=34016--appendix-a-submissions-and-comments Accessed 28 July 2022.
2129. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian Government response to the state of the environment 2018 report', Melbourne, Victoria.
2130. Ibid.

Waste and resource recovery

The circular economy monitoring and evaluation framework will be coordinated by Recycling Victoria's (RV) data team and serve to track Victoria's transition to a circular economy.

Recommendation 14 of the SoE 2018 Report recommended:

> *That the Victorian Government, commencing within the metropolitan region as a minimum, align the institutional planning and procurement processes (including leveraging Victorian Government procurement) to support the delivery of the circular economy strategy from July 2020. Ultimately, this alignment would be adopted statewide and enable an orderly transition to a circular economy in Victoria by 2030. In developing the action plan to deliver the circular-economy strategy, the roles and responsibilities of all agencies should be clarified to nominate those agencies responsible for delivering policy, procurement, program, reporting and regulatory roles. Further, that the Victorian Government commit to long-term, systemic, statewide community education to support this transition and assist the change in behaviours that will be required to improve long-term system outcomes. Reducing consumption and contamination levels in household recycling would be the initial focus.*

Government response in 2020:

SUPPORT

'The Victorian Government supports this recommendation.' [2131]

'The Government recognises the importance of transitioning to a circular economy. The Government published a circular economy policy on 26 February 2020 that fulfils this recommendation and provides a plan to transition to a more circular economy, with ambitious 2030 targets.' [2132]

'Recycling Victoria: A New Economy details a package over $300 million to deliver recycling reforms and investment. The policy provides a pathway for Victoria to reduce the environmental impacts of production and consumption, while maintaining or increasing the value people obtain from goods and services.' [2133]

'Under this plan, we'll overhaul our household recycling services, introducing a 4-stream system and a container deposit scheme to improve the value captured from the materials we recycle. We'll also introduce new legislation and establish a waste authority to ensure greater accountability and transparency and improve services. Implementing behaviour change programs across Victoria is included in the policy. A statewide education and behaviour change program will be critical to ensure Victorians understand how to use the new system effectively. Better sorting habits mean we will be able to use more of the materials collected from households to make new products.' [2134]

'Recycling Victoria: A New Economy will be delivered by agencies across the Victorian government, in line with the Government's waste and resource recovery portfolio agencies roles and responsibilities document.' [2135]

'The Victorian Government also recognises that local government is a critical delivery partner in Victoria's waste and resource recovery system and is committed to continuing to work closely with local governments and peak associations to understand opportunities and concerns of these communities.' [2136]

2131. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Victorian Government response to the state of the environment 2018 report', Melbourne, Victoria.
2132. Ibid.
2133. Ibid.
2134. Ibid.
2135. Ibid.
2136. Ibid.

Waste and resource recovery

Progress made since 2018

Since the launch of the circular economy policy in 2020, $515 million has been invested to transform Victoria's waste and recycling system, which includes:

- investment of $96 million towards new infrastructure and innovation
- establishment of new laws that support Victoria's transition to a circular economy
- establishment of a new waste and recycling sector regulator, RV, to support and strengthen the sector, oversee markets and ensure households and businesses receive reliable consistent services.
- investment of $129 million to support local governments in the introduction of the new statewide standardised household four-stream waste and recycling system.

Implementation of the standardised statewide four-stream household waste and recycling system has commenced. The Department of Energy, Environment and Climate Action (DEECA) continues to work with all 79 local governments and Alpine Resorts to roll out the new four-stream household waste and recycling system across Victoria.

Victoria's Container Deposit Scheme is due to begin 1 November 2023. The government is now in the final stages of a competitive process to appoint a scheme coordinator and network operator or operators.

Legislation was passed by the Parliament of Victoria in 2022, enabling RV to administer a new waste to energy licensing scheme. This will allow waste that cannot be recycled to be used in waste to energy facilities. DEECA is currently developing regulations that will allow existing thermal waste to energy projects (those with planning permits already in place as of 1 November 2021) to apply to RV for an existing operator licence.

On 1 February 2023, Victoria had commenced a statewide ban on a range of single-use plastics, including straws, cutlery, plates, drink stirrers, cotton bud sticks and expanded polystyrene food and drink containers, to address plastic pollution.

The Circular Economy Business Innovation Centre is working within businesses to promote innovative solutions for avoiding, minimising and repurposing material that would otherwise go to waste.

The Victorian Government developed and released Regional Circular Economy Plans in 2022 that work towards highlighting opportunities, tackling challenges, and guiding investment in regional circular economies.

The Small Acts Make a Big Impact campaign was launched in May 2022 and has focused on several key behaviours — both in correctly sorting and disposing of items at the end of their life and avoiding waste entering the system, particularly food and single-use plastic waste. This campaign is being used by councils across Victoria when communicating the changes to their household recycling services and introducing new bins to communities.

Background

Take, make, dispose. This throw-away approach is the basis of a linear economy. The cycle begins with virgin materials being removed from the earth to manufacture into new products. Additional inputs of water and energy are also used to compensate for processing system inefficiencies. Products flow onwards through distribution channels to consumers, and once used, they ultimately exit the system as waste where the value of their constituent materials is lost. The higher the demand for products by consumers the greater the rate at which the 'take-make-discard' cycle occurs. Inbuilt product obsolescence also acts in propelling the pace of the 'take-make-discard' cycle even further, as shortened product lifespans and limited capacity for low-energy pathways of reuse require more rapid and continuous replacement.

This linear economic model is not only highly inefficient, but it also places intense pressures on the natural environment, resulting in a substantial ecological footprint.[2137] Extraction processes deplete finite natural resource stocks to meet excessive production demands.[2138] Water and energy inputs used to drive the manufacturing and distribution of products exacerbate the issues of water scarcity and climate change, while the waste and emissions which are generated accumulate as the product travels along the supply chain. The longer the supply chain, the greater the cumulative impacts. Once products are consumed and disposed to landfill, waste by-products can emit harmful pollutants that further contribute to greenhouse gas emissions and impact the health of humans and biodiversity.[2139] And, as waste facilities are typically developed and operated in close proximity to disadvantaged communities, the negative effects are disproportionately higher among these groups, increasing their vulnerability and exasperating the issue of social inequality.[2140] There is also a large economic toll that arises from a linear model. Governments lose millions of dollars annually from managing the growing amounts of waste being generated and landfilled.[2141]

A recycling model is a step-change from the linear approach to production and consumption, which places focus on the end of the product lifecycle. When products reach their end-of-life, useful materials are recovered and processed for reuse.

Victoria has been operating under this recycling economic system as a way of managing its growing issue of waste and minimizing the associated environmental pressures that flow on from rising waste levels. During the last decade (2010-2020), the state saw a gradual rise in resource recovery, where the amount of material recovered increased from 8.1 Mt to 11.1 Mt.[2142] Yet, despite this encouraging movement towards higher levels of recovery over this period, Victoria's diversion rate had not kept pace with the rising levels of waste being generated. Total waste generation rose by 25%, peaking at 15.9 Mt in 2020. While the amount of waste being diverted from landfill, by contrast, had only a 10% increase overall, and decreased in 2019-20. This means that progressively more waste has been ending up in landfill each year (since 2013-14).[2143] Plastics continued to be recovered at a low rate, while end-of-life management issues are emerging for other waste streams, like e-waste.[2144, 2145]

2137. Cramer J 2020, 'The function of transition brokers in the regional governance of implementing circular economy—A comparative case study of six Dutch regions', Sustainability, 12(12), pp. 1-21 https://www.researchgate.net/publication/342328715_The_Function_of_Transition_Brokers_in_the_Regional_Governance_of_Implementing_Circular_Economy-A_Comparative_Case_Study_of_Six_Dutch_Regions Accessed 18 July 2022.
2138. Otter C 2018,'The circular economy: An explainer', Research Note. Parliament of Victoria: Department of Parliamentary Services, https://www.parliament.vic.gov.au/publications/research-papers/download/36-research-papers/13880-the-circular-economy-an-explainer Accessed 21 September 2022.
2139. Suave S, Bernand S and Sloan P 2016, ' Environmental sciences, sustainable development and circular economy: Alternative concepts for trans-disciplinary research' Environmental Development, 17, pp. 48-56.
2140. RTS 2022, 'Where does my waste go', https://www.rts.com/blog/where-does-my-waste-go-a-guide-to-measuring-diversion-and-tracking-progress-for-businesses/ Accessed 4 January 2023.
2141. The World Bank 2022, 'What a waste 2.0: A global snapshot of solid waste management to 2050', https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html Accessed 11 September 2022.
2142. Ibid.
2143. Ibid.
2144. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Recycling industry waste report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Recycling-Industry-Report-2019-20.pdf Accessed 30 June 2022.
2145. Infrastructure Victoria (IV) 2020, 'Advice on recycling and resource recovery infrastructure', Melbourne, Victoria, https://www.infrastructurevictoria.com.au/wp-content/uploads/2020/03/Advice-on-recycling-and-resource-recovery-FINAL-REPORT.pdf Accessed 29 July 2022.

Waste and resource recovery

Spurring much of the pattern of resource recovery exhibited in Victoria was a series of extraordinary circumstances, starting with the strict enforcement of China's National Sword policy in 2018, followed by market disturbances and local reprocessing shortfalls, and ending with a surge in the stockpiling and disposal of household recyclable materials. In 2019-20 alone, Victoria landfilled an estimated 4 Mt of recyclable material, contributing nearly 3 Mt (3%) to the state's total greenhouse gas emissions, while local governments spent approximately $556 million towards managing household waste.[2146, 2147]

Collectively, these forces not only exposed the vulnerabilities within Victoria's waste and resource recovery sector, but also the limitations that a recycling economic model has towards reducing waste levels and mitigating the environmental and financial impacts associated with production and consumption.

Recycling as an end-of-pipe solution is not enough for easing environmental pressures or overcoming the sheer magnitude of waste being generated in Victoria, in that this economic model only targets the issues arising at the disposal stage of the product life cycle, as opposed to reducing environmental dependencies and preventing the generation of waste and pollution in the first place. A circular economy is seen as the pathway towards a more sustainable future by addressing issues at the source. Unlike the linear and recycling economic models, a circular economic model is a restorative, closed-loop system underpinned by three principles:

- elimination of waste
- circulation of products and materials at their highest value
- regeneration of nature.

Recognising the limited contributions recycling alone provides towards reducing waste loads and environmental pressures, the Victorian Government released its new waste policy, Recycling Victoria: A New Economy, in February 2020 which is aimed at transitioning the state to a circular economy. The policy puts forth a roadmap for achieving targets towards:

- reducing waste generation and organic waste disposal
- increasing the amount of waste diverted from landfill
- reforming and standardising household recycling systems.

To evaluate the effectiveness of initiatives in meeting the state's targets, and to track Victoria's overall progress towards a circular economy, development of a monitoring and evaluation framework was established as a key government commitment under the circular economy policy.

The current set of state of the environment waste and resource recovery indicators, while useful in terms of affording a preliminary picture of Victoria's transition to a circular economy, will ultimately be expanded and directly map against the metrics of the circular economy and evaluation framework, once released. This alignment between the Government framework and state of the environment reporting will enable Victoria's progress in the uptake of circular principles across all elements of the state's economy to be comprehensively assessed, and recommendations developed which help address identified barriers within the transition process and improve environmental outcomes.

The indicator assessments in this report do, however, afford some insight into how well Victoria is eliminating waste and pollution (W:01, W:02, W:03, W:05, and W:06) and circulating products and materials within the economy (W:04). With results indicating a lack of circularity within Victoria's economy in that the Recycling Victoria: A New Economy policy ambitions for reducing levels of per capita waste and food waste generation, and increasing the rate of waste diversion, are not on track to meet the 2030 targets – nor has waste generation as yet demonstrated a decoupling with socio-economic markers that is typically expected under a circular economy.[2148] It is important to note, however, that some delay between policy changes, data collection and updated reporting regimes are to be expected due to Covid-19.

2146. Department of Environment, Land, Water and Planning (DELWP) 2021, ' Waste sector emissions reduction pledge', https://www.climatechange.vic.gov.au/victorian-government-action-on-climate-change/Waste-sector-pledge-accessible.pdf.

2147. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.

2148. Sustainability Victoria (SV) 2020, 'Victorian local government annual waste services report 2018-19', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Local-Government-Annual-Waste-Services-Report-2018-19.pdf Accessed 30 June 2022.

Waste and resource recovery

As Victoria moves forward in its transition to a circular economy, the state is faced with the following challenges in establishing the essential architecture necessary to support a circular economy and meeting targets set under the circular economy policy:

- providing comprehensive waste data systems and reporting
- fulfilling identified resource recovery infrastructure capacity and capability shortfalls
- avoiding and reducing waste across waste streams and source sectors
- producing high quality recyclable materials
- eliminating pollution
- managing unintended and emergent contaminants.

Policy and legislative settings

Victoria's roadmap to a circular economy

Aimed at building resilience against external drivers, and transitioning Victoria to a circular economy, the Victorian Government released Recycling Victoria: A New Economy in February 2020. The policy is underpinned by a new legislative framework that gives effect to its key commitments and establishes a new waste authority.

The Recycling Victoria: A New Economy policy and action plan serves to transform Victoria's waste and recycling system and provide a roadmap for operationalising circular principles in the state's supply chains to transition Victoria to a circular economy.[2149]

The policy puts forth four targets for 2030 which also complements the national waste policy:

- Target 1: Divert 80% of waste from landfill, with an interim target of 72% by 2025.
- Target 2: Cut total waste generation per capita by 15%.
- Target 3: Halve the volume of organics going to landfill, with an interim target of a 20% reduction by 2025.
- Target 4: Ensure every Victorian household has access to food and garden organic (FOGO) waste recycling services or local composting.

The Victorian Government has committed to developing a monitoring and evaluation framework (MER) to evaluate its implementation. This MER framework also forms part of the Government's response to Recommendation 13 of the SoE 2018 Report.

Legislation for the delivery of a circular economy in Victoria

The *Circular Economy (Waste Reduction and Recycling) Act 2021*, passed in December 2021, lays the foundation for Victoria's transition to a circular economy and establishes a legislative framework to give effect to some of the key commitments of the circular economy policy, including:

- Establishing the Head, RV, within the Department of Energy, Environment and Climate Action (DEECA) as a regulator that will provide strategic leadership and oversight for the waste, recycling and resource recovery sector. The services previously afforded by the Waste and Resource Recovery Groups under the *Environment Protection Act 2017* (EP Act) will transfer to RV, and be expanded upon, to deliver a broader functional remit.
- Setting and enforcing standards and regulations which can apply to providers of waste, recycling or resource recovery services and waste streams.

[2149] Department of Environment, Land, Water and Planning (DELWP) 2020, 'Recycling Victoria: A new economy', Melbourne, Victoria, https://www.vic.gov.au/transforming-recycling-victoria Accessed 30 June 2022.

- Implementing mandated expansion and improvements for data collection and reporting requirements from entities in the waste and recycling sector to provide transparency and accountability for what happens to the state's waste. The establishment of a framework for monitoring progress towards the circular economy, including the identification of indicators and metrics, is also part of this expanded data system.
- Creating a legislative obligation for local governments and alpine resort management boards to provide households with access to a 4-stream waste collection system by 2030.
- Delivering a Container Deposit Scheme to be administered by RV.

In September 2022, the *Environment Legislation Amendment (Circular Economy and Other Matters) Act 2022* received Royal Assent which amends the Circular Economy Act and the EP Act to increase regulatory efficacy of the state's circular economy, environment protection and environmental sustainability.[2150] Specifically, the reform:

- Introduces a single Victorian Recycling Infrastructure Plan that replaces the existing documents under the *Environment Protection Act 2017* and provides long-term strategic planning for the state's waste, recycling and resource recovery infrastructure.
- Establishes a framework for the allocation of licenses to waste-to-energy facilities and specification of an annual cap for new operations on the amount of waste sent to thermal waste-to-energy facilities.[2151]
- Provides for powers relating to the circular economy market, including those powers relating to risk, consequences, and contingency planning for the circular economy.
- Provides for matters relating to compliance and enforcement.

The Environment Legislation Amendment Act also makes consequential amendments to the *Sustainability Victoria Act 2005*, the Climate Change Act, and the *Victorian Civil and Administrative Tribunal Act 1989*.

A regional approach to Victoria's circular economy

In October 2022, Regional Circular Economy Plans (RCEPs) were released for each of Victoria's five regions. The RCEPs set out statements of intent for each region's circular economy aspirations and priorities to 2030, as well as the pathway to achieve them.[2152] Based on insights into each region's distinct set of strengths and challenges, the RCEPs will be used to inform government policy, regional and infrastructure planning, program design and implementation as a way of strengthening circular economy opportunities and supporting the delivery of Victoria's circular economy policy across the state.

Changing recycled material standards within infrastructure projects

The Recycled First policy came into effect in March 2020 to support the goals of the state's circular economy policy. Recycled First mandates that, where appropriate, recycled and reused materials are to be used in all new major transport infrastructure projects (undertaken by delivery agencies) as a way of promoting greater use of recycled materials, accelerating innovation and implementation of new Victorian recycled products, and developing new markets. The policy also requires successful tenderers to report against their Recycled First commitments during delivery as a way of increasing the Government's information base to better identify supply and demand in the market as well as the state's future infrastructure needs.

[2150] Office of the Chief Parliamentary Counsel Victoria 2022, '*Environment Legislation Amendment (Circular Economy and Other Matters) Act 2022*'', Melbourne, Victoria. https://www.legislation.vic.gov.au/bills/environment-legislation-amendment-circular-economy-and-other-matters-bill-2022 access 21 September 2022.

[2151] The requirement to fit within the 1 million tonne cap limit does not apply to thermal waste to energy facilities that were operating, or had an approved planning permit, before 28 June 2021. These facilities will, therefore, not be assessed against the evaluation criteria detailed in Section 3.4 of the Victorian Waste to Energy Framework, but instead, will automatically be granted a cap licence following receipt of a completed application.

[2152] Victorian Government 2022, 'Regional circular economy plans' https://www.vic.gov.au/regional-circular-economy-plans Accessed 22 November 2022.

A preventative approach to managing waste hazards

The state's new circular economy policy is also supported by the modernisation of the waste management framework under the amended EP Act, which took effect on 1 July 2021 and provides Environment Protection Authority (EPA) Victoria with enhanced powers to better protect human health and the state's environment. The new, pro-active approach is focused on preventing waste and pollution impacts, while also supporting the reuse and recovery of waste material in line with the state's circular economy policy. The key reforms within the new framework include:

- annual indexation of waste levies
- general environmental, industrial, priority waste and contaminated land duty requirements
- site management orders
- a three-tiered permissions system
- proportionate enforcement actions for legislative breaches
- strengthened compliance and enforcement powers
- community rights

Environmental reporting by government agencies

The Financial Reporting Directive (FRD) 24 was introduced June 2022 and supersedes FRD 24D (May 2018).[2153] FRD 24 mandates that Victorian Government entities report on aspects of energy and resource consumption and environmental performance within their Annual Report of Operations. The directive applies to all defined entities that are classified into reporting tiers, with each tier being subject to different disclosure requirements that are scaled to entity size and impact.[2154]

Specifically, entities must disclose information on:

- electricity production and consumption (4 required indicators)
- stationary fuel use (2 required indicators)
- transportation (4 required indicators; 4 optional indicators)
- total energy use (4 required indicators)
- sustainable buildings and infrastructure (5 required indicators; 2 optional indicators)
- sustainable procurement (1 required indicator; 2 optional indicators)
- water use (2 required indicators)
- waste and recycling (5 required indicators; 1 optional indicator)
- greenhouse gas emissions (3 required indicators; 5 optional indicators).

Investigations into Victoria's waste and resource recovery sector

Two Victorian Auditor-General's Office audits and a Parliamentary inquiry have been undertaken since the publication of the SoE 2018 Report which are highly relevant towards improving the management of Victoria's waste and resource recovery sector and promoting positive environmental outcomes. The broad focus of the reports include:

- recovering and reprocessing resources from waste[2155]
- recycling and waste management[2156]
- managing the municipal and industrial landfill levy.[2157]

[2153] Victoria State Government 2022, 'Reporting of environmental data by government entities', Melbourne, Victoria, https://www.dtf.vic.gov.au/sites/default/files/document/FRD%2024%20Reporting%20of%20environmental%20data%20by%20government%20entities.DOCX Accessed 2 October 2022.

[2154] Entities under the Financial Reporting Directive 24 is defined as either a public body or a department under section 3 of the *Financial Management Act 1994*, with the exception of universities.

[2155] Victorian Auditor-General's Office (VAGO) 2019, 'Recovering and reprocessing resources from waste: Independent assurance report to Parliament', Melbourne, Victoria, https://www.audit.vic.gov.au/node/33226 Accessed 28 July 2022.

[2156] Legislative Council Environment and Planning Committee Parliament of Victoria 2019, 'Inquiry into recycling and waste management', Melbourne, Victoria, https://www.parliament.vic.gov.au/file_uploads/LCEPC_59-02_Inquiry_into_recycling_and_waste_management___6hNrvBj7.pdf Accessed 28 July 2022.

[2157] Victorian Auditor-General's Office (VAGO) 2019, Managing the municipal and industrial landfill levy', Melbourne, Victoria, https://www.audit.vic.gov.au/report/managing-municipal-and-industrial-landfill-levy?section= Accessed 17 February 2023.

Indicator Assessments

Refer to 'Guide to the indicator assessments' at the start of Part 3 for the accompanying definitions and legends related to the indicator assessment summary tables.

There are some overarching qualifications and/or limitations to the assessments specific to the indicators within this chapter. These are outlined below.

Each year, the Victorian Government collates critical data on waste management, recovery and reprocessing from across the state and presents annual performance and trends within the Recycling Industry Waste Report (RIWR) and Local Government Waste Services Report (LGWSR). The data which serves as the basis of the two annual reports are sourced from EPA Victoria data on quantities sent to landfill, Australian Bureau of Statistics commodity export data, and annual waste surveys involving reprocessing organizations, Victorian local governments, and plastic recyclers.

While the data collected through the annual surveys represent the official statistics used to inform much of the policy decision-making and programs, it is important to note that there are inherent limitations surrounding the data captured through the survey process, primarily due to the data collection systems and methodologies that were used, as well as the approach used in calculating the annual waste statistics. The limitations include:

- incomplete data due to survey participation being voluntary and the provision of partial data by some participants
- estimated tonnages of waste by source sector and waste stream rather than actual measured weights
- use of comparative analyses as the primary data validation and quality assurance technique
- lack of comprehensive food waste generation statistics due to combining this type of waste within the organic waste stream and excluding the primary production source sector
- stockpiled materials are only included within annual waste calculations in the year in which they are cleared from storage and continue onwards to their end-of-life destination (landfill, local reprocessing, export), as opposed to the year they are generated.

Collectively, the above limitations affect the quality and accuracy of the data within the RIWR and LGWSR reporting. Deferring stockpiled waste amounts, in particular, not only distorts the annual figures around waste generation and recovery, but also hinders accurate assessment of Victoria's performance towards its circular economy targets.[2158] Given that the statistics derived from the RIWR and LGWSR reports used in assessing the state of the environment Indicators W:01 to W:04 were subject to the above limitations, which were not apparent in the SoE 2018 Report, data confidence has changed from good to poor. Indicators W:05 and W:06 were not affected by these limitations as the data were primarily derived from other sources.

SoE indicator suite adjustments

State of the environment indicators are the foundational tools for evaluating and communicating the impact our activities have on the environment. The assessments of SoE 2018 indicators provided a scientific baseline of the state of Victoria's environment from which future SoE reports build upon.

However, as new pressures, challenges and data sources emerge, the SoE indicator suite must also evolve to ensure their collective assessments provide a comprehensive account of the condition of Victoria's natural values. The SoE 2023 indicator suite has been adjusted, with some new indicators being introduced and some existing indicators either being disaggregated to improve the focus of assessments, merged to enable inter-connected indicators to be evaluated as a whole, superseded, or modified in terms of the scope, breadth of measures or to align with policy targets. Refer to Appendix C of the Summary Report for a complete account of the changes that have been made to the SoE 2018 indicator suite in this report.

Changes to the indicator suite for this chapter are outlined below:

- The measure for the SoE 2023 indicator 'W:02 Generation of waste per capita' has broadened from that of the SoE 2018 indicator 'W:02 Generation of municipal waste per capita' to include waste generation from both the MSW and C&I sectors, as opposed to being restricted to only MSW waste, in order to align with that of the circular economy policy target.

[2158] Legislative Council Environment and Planning Committee Parliament of Victoria 2019, 'Inquiry into recycling and waste management', Melbourne, Victoria, https://www.parliament.vic.gov.au/file_uploads/LCEPC_59-02_Inquiry_into_recycling_and_waste_management__6hNrvBj7.pdf Accessed 28 July 2022.

Waste and resource recovery

Waste

Indicator W:01 Total waste generation

W:01 Total waste generation

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴	↙	🟡	🟡	→	🟢

Data source(s):	SV
Measure(s):	Annual amount of managed waste generated (tonnes) by all source sectors, not including hazardous waste

Why this indicator?

Depending on how it is managed, as well as its composition, waste can have significant social, economic and environmental impacts. GHGs, particulate matter and other pollutant by-products are emitted into the atmosphere from the transport, disposal and reprocessing of waste. These contribute to climate change and reduce air quality, which has implications for human health. Hazardous leachates produced by landfilled waste can contaminate surrounding soil and groundwater systems, threatening biodiversity and degrading ecosystems. Disposed materials represent a loss of natural resources and other inputs used in the product chain, such as water and energy, which can further impact water scarcity and the depletion of natural resources. The financial burden incurred by governments and communities also increases, as the management of higher volumes of waste demands more waste management and material recovery infrastructure.

Criteria used for status assessment

No national or statewide standards, thresholds or strategic targets currently exist for waste generation. The assessment in the SoE 2023 Report is based upon comparisons with the data used in determining the status and trend within the SoE 2018 Report.

Why this assessment in 2023?

Total waste generation has been on an upward trajectory from 2014–15 to 2019–20, following a short period of decline from 2012–13 to 2013–14. In 2019–20, Victoria had discarded more waste than in any other year.

The amount of waste produced increased at a more rapid rate (10%) and peaked at a higher level (15.9 Mt) during the SoE 2023 reporting period than what was demonstrated during the SoE 2018 reporting period (7% and 12.9 Mt, respectively). The construction and demolition (C&D) sector contributed nearly half of the state's total generated waste during 2018–19 and 2019–20, primarily due to a sharp rise in aggregates, masonry and soil waste prompted by an upturn in infrastructure development projects. By contrast, waste levels were comparably lower among the municipal solid waste (MSW) and commercial and industrial (C&I) sectors.

COVID-19 restrictions and kerbside waste collection system reforms affected the patterns of waste generation among the C&I and MSW sectors between 2018–19 and 2019–20, leading to increasing levels of household organics and glass, and reductions in the generation of these waste streams by business and industry.

Due to issues associated with the quality and comprehensiveness of annual waste data, highlighted by several recent audit and inquiry reports, coupled with a lack of established thresholds or policy targets for this indicator, the data confidence has been assessed as moderate.

Summary of State of the Environment 2018 Report assessment

- The total of amount of waste generated in Victoria between 2012-13 and 2016-2017 trended upwards, gradually rising year on year from 12.0 Mt in 2012-13 to 12.9 Mt during 2016-17. The overall rate of increase in generated waste during this 5-year period was 7%, with an average 1% annual rate of increase.
- No information regarding total generation by waste stream or source sector was available within the annual waste reports during the SoE 2018 reporting period.

Critical data used for the 2023 assessment

- Waste and Recycling in Victoria – Recycling Industry Workbook 2019-20

2023 assessment

Waste is generated by economic activity, and is a by-product of contemporary life. Under the conventional linear take-make-dispose model, the volume of waste that is generated typically is tightly correlated and trends in line with socioeconomic factors, namely population growth and GSP.[2159]

The relationship between total waste generation and socio-economic factors observed in Victoria mirrored that of a linear model, where population, GSP and waste generation each increased over the past 10 years.[2160] On average, Victoria's population, GSP and waste generation all had grown by similar amounts (2%, 4%, and 3%, respectively). Peak growth in generated waste occurred within 2017-18 (12%) and again in 2018-19 (6%; Figure W1). This spike in waste generation was attributed to greater levels of construction and demolition activity as well as the clearance of stockpiled material from previous years.[2161] By 2019-20, Victoria had generated more waste than it has in any other year, reaching 15.9 Mt.

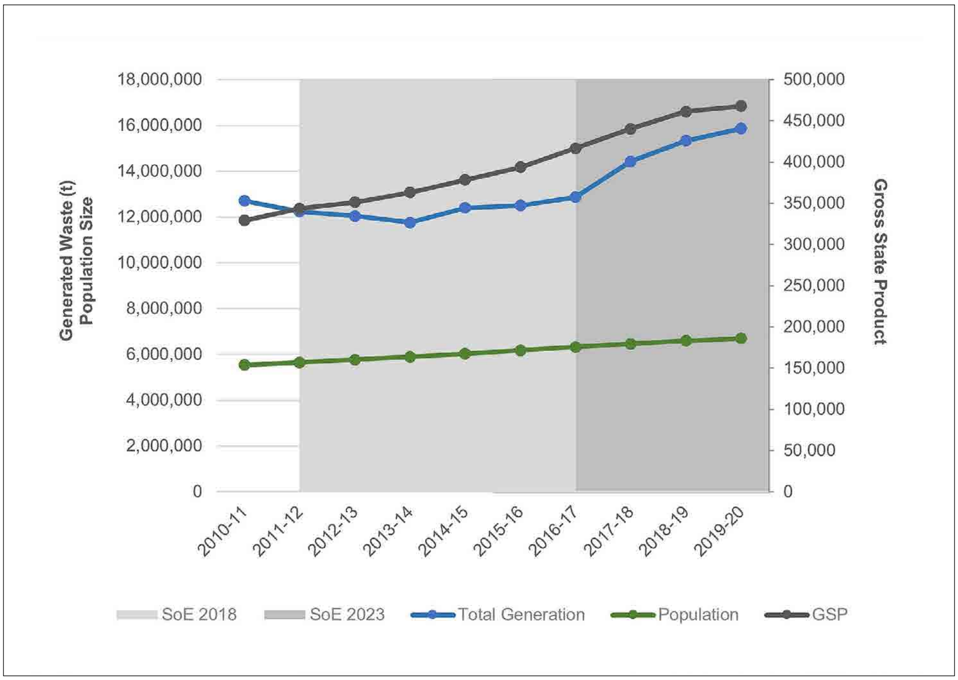

Figure W1: Annual amount of total waste generated, population, and GSP in Victoria between 2010-11 and 2019-20.[2162] Light and dark time series denote state of the environment reporting periods. Waste generation increased overall by 7% during the SoE 2018 reporting period while generated increased overall by 10% during the SoE 2023 reporting period.

To accommodate the state's growing population, there has been a recent surge in land development and major public transport infrastructure projects.[2163] This has led to a sharp rise (24%) in the number of aggregates, masonry and soil waste generated and has made the C&D sector the largest contributor to statewide waste totals between 2018-19 and 2019-20 (Figure W2).

2159. Van Fan Y, JJ Klemeš, CT Lee, RR Tan 2021, 'Demographic and socio-economic factors including sustainability related indexes in waste generation and recovery', Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, https://ans.tandfonline.com/doi/pdf/10.1080/15567036.2021.1974610 Accessed 25 January 2023.
2160. Total waste generation is calculated by adding the waste recovered from all source sectors reported within the RIWR, EPA landfill data, and ABS export data.
2161. Sustainability Victoria (SV) 2019, 'Victorian recycling industry annual report 2017-18', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Recycling-Industry-Annual-Report-2017%E2%80%9318.pdf Accessed 30 June 2022.
2162. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria – recycling industry workbook 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Workbook-Waste-Recycling-Industry-Workbook-2019%E2%80%9320.xlsx Accessed 5 July 2022.
2163. Blue Environment 2020, 'National waste report 2020', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-report-2020.pdf Accessed 4 July 2022.

Waste and resource recovery

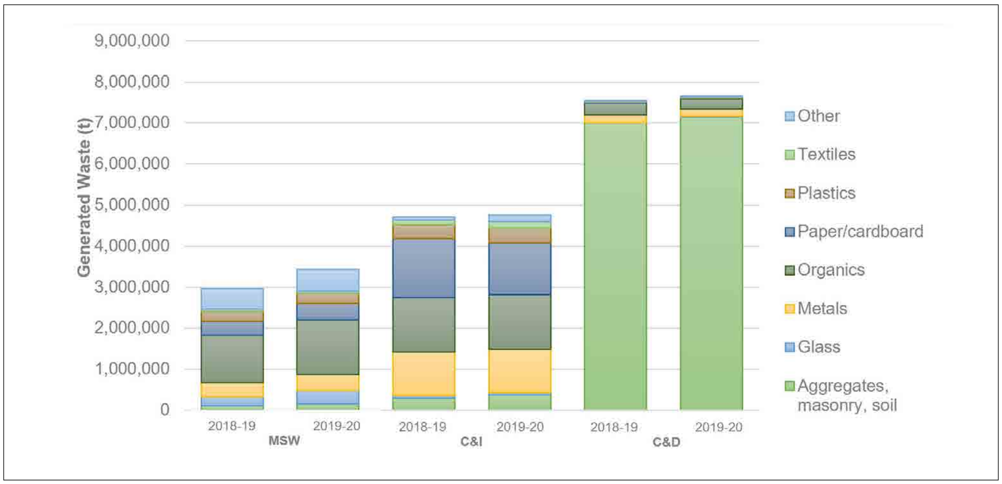

Figure W2: Comparison of the total amount of each waste stream by source sector during 2018-19 and 2019-20.[2164]

Waste generation among the MSW and C&I sectors, by contrast, had contributed far less materials (21% and 30%, respectively) to the statewide waste totals. COVID-19 lockdown measures impacted the patterns of waste generation by business and households during 2018-19 and 2019-20, where restrictions to business operations and stay-at-home directives caused marked shifts in generated waste from the C&I sector to the MSW sector. As a result, C&I waste generation remained relatively stable from 2018-19 (4.7 Mt) to 2019-20 (4.8 Mt) while the MSW sector exhibited the largest upturn (16%) in waste levels relative to all other sectors. (C&I: 1%; C&D: 1%). Household recyclables, particularly organics and glass, all rose between 2018-19 and 2019-20, whereas these same waste streams declined among business and industry. Other factors, in addition to COVID-19, were also identified as significant forces driving the observed rise in household recyclables during this period, including:

- expanded access to FOGO bin services under household recycling system reforms [2165]
- the storage and subsequent clearance of stockpiled kerbside recyclable materials, including glass, to landfill arising from the closure of the SKM material recovery facility.[2166]

Despite the continued growth in waste generation that has been occurring in Victoria since 2014-15, the rate of increase has begun to slow in recent years, hinting at a potential shift in behaviour. Further reduction in the rate of waste generation may occur in the coming years from the delivery of a suite of waste avoidance and reduction initiatives put forth under the circular economy policy.[2167, 2168, 2169, 2170] However, should the conventional linear production and consumption model remain largely embedded and the upward trajectory of waste generation in Victoria continue, it is projected that the quantity of waste that will be generated statewide will climb to 17.8 Mt by 2030.[2171] With this comes the significant challenge for expanding infrastructure capacity to overcome identified shortfalls and effectively coping with the demands and costs of managing larger volumes of waste.[2172]

2164. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria – recycling industry workbook 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Workbook-Waste-Recycling-Industry-Workbook-2019%E2%80%9320.xlsx Accessed 5 July 2022.
2165. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Recycling industry waste report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Recycling-Industry-Report-2019-20.pdf Accessed 30 June 2022.
2166. Ibid.
2167. Sustainability Victoria (SV) 2022, 'Circular Economy Business Support Fund – Round 2, Stream 1: Develop a circular economy business case', https://www.cebic.vic.gov.au/grants-funding-and-investment/grants-and-funding/business-support-fund-round-2-stream-1 Accessed 2 November 2022.
2168. Sustainability Victoria (SV) 2022, 'Circular Economy Business Support Fund – Round 2, Stream 2: Implement a circular economy business case', https://www.cebic.vic.gov.au/grants-funding-and-investment/grants-and-funding/business-support-fund-round-2-stream-2 Accessed 2 November 2022
2169. Sustainability Victoria (SV) 2022, 'Circular Economy Innovation Fund – Round 2, Stream 2: Collaborative innovation', https://www.sustainability.vic.gov.au/grants-funding-and-investment/grants-and-funding/circular-economy-innovation-fund-round-2-stream-2-collaborative-innovation Accessed 2 November 2022.
2170. Sustainability Victoria (SV) 2022, 'Circular Economy Communities Fund – Round 2, Stream 2: Regional community projects', https://www.sustainability.vic.gov.au/grants-funding-and-investment/grants-and-funding/circular-economy-communities-fund-round-2-stream-2-regional-community-projects Accessed 2 November 2022.
2171. Sustainability Victoria (SV) 2022, 'Waste projection model', Melbourne, Victoria, https://www.sustainability.vic.gov.au/research-data-and-insights/waste-data/interactive-waste-data/victorias-waste-projection-model Accessed 18 July 2022.
2172. Infrastructure Victoria (IV) 2020, 'Advice on recycling and resource recovery infrastructure', Melbourne, Victoria, https://www.infrastructurevictoria.com.au/wp-content/uploads/2020/03/Advice-on-recycling-and-resource-recovery-FINAL-REPORT.pdf Accessed 29 July 2022.

Waste and resource recovery

Indicator W:02 Generation of waste per capita

W:02 Generation of waste per capita

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🟡	?	🔴	🟡	→	🟢

Data source(s):	ABS, SV
Measure(s):	Annual amount of non-hazardous waste generated from the MSW and C&I sectors per person (kg)

Why this indicator?

Waste per capita provides a metric for assessing individual waste generation by accounting for changes in population levels. In having a clear understanding of the true pattern of waste generation, the efficacy of policy and programs aimed at reducing waste generation can be evaluated, as can progress towards targets under the circular economy policy.

NB: The measure for this modified SoE 2023 has broadened from that of the SoE 2018 indicator 'W:02 Generation of municipal waste per capita' to include waste generation from both the MSW and C&I sectors in order to align with that of the circular economy policy target.

Criteria used for status assessment

Good: Achieving Victoria's target of 15% reduction in waste per capita by 2030 (based on waste projection models) [2173]

Fair: Achieving within 5% of Victoria's target of reduction in waste per capita (10%–14%) by 2030 (based on waste projection models)

Poor: Achieving less than 10% reduction in waste per capita by 2030 (based on waste projection models)

Why this assessment in 2023?

Waste generation per capita exhibited a gradual increase across 2017–18 and 2019–20. However, it is important to note that comparisons with assessment results from the SoE 2018 Report cannot be undertaken as the calculations for per capita waste have been modified in the SoE 2023 Report.

Recyclable material made up more than half (54%–56%) of per capita waste totals annually. However, with continual growth in the amount of garbage generated per person across the 3-year period, the rate of diversion from landfill declined. It is projected that, by 2030, waste generation per capita will be 10% less than it was in 2018–19 (baseline). Although this exceeds the state reduction target of 15%, it does meet the more conservative national target, which aims for a 10% reduction.

The true pattern of per capita waste over the 3-year period was affected by the influx of large quantities of stockpiled household recyclables that were released from storage and managed. Whether further impacts from the clearance of stored materials on per capita waste generation are unclear, as information on stockpiling is not consistently disclosed by annual waste survey participants.

Data confidence was rated as low due to the issues of data quality and limited data availability.

Summary of State of the Environment 2018 Report assessment

- Municipal per capita waste in Victoria exhibited an overall 3% decrease between 2013-14 (359 Kt) to 2015-16 (347 Kt). Waste volumes per person then rose slightly to 353 Kt.
- The amount of garbage and recyclables per person declined across the 5-year period. By contrast, the amount of organic waste per person increased between 2013 and 2017, likely due to greater availability of organic waste collection services.
- Each year, garbage represented the largest component of per capita waste, ranging between 53% to 54%.

2173. SV has developed a waste projection model which tracks and projects future solid waste flows in Victoria using two sources of information, one being the total amount of waste recovered derived from the Victorian Recycling Industries Annual Survey and the second being EPA data on the amount of material deposited at landfills. Future projections are based on the last known landfilled figure and projected into the future using population estimates. The interactive dashboard is publicly available and is accessed at https://www.sustainability.vic.gov.au/research-dataand-insights/waste-data/interactive-waste-data/victorias-waste-projection-model. It should be noted that the predictive modelling is expected to be updated during 2023 which may have different projections for 2030 than reported within the SoE 2023 Report.

Waste and resource recovery

Critical data used for the 2023 assessment

- Waste Projection Model 2022 Dashboard[2174]
- Victorian Recycling Industry Annual Report 2017-18
- Victorian Recycling Industry Annual Report 2018-19
- Waste and Recycling in Victoria: Recycling Industry Waste Report 2019-20

2023 assessment

Population size is tightly linked to waste generation and can act in masking the true patterns of material disposal and recovery. Waste generation per capita removes the effects of population fluctuations to determine waste levels per person, thereby providing a more accurate measure for assessing trends in waste generation.

Under the circular economy policy, Victoria's target is to achieve a 15% reduction in waste per capita by 2030 (from a 2018-19 baseline). Per capita waste in this context is defined as the total mass of all material types entering the waste management system from the MSW and C&I sectors divided by state population. The C&D sector is excluded from the calculation, as waste arising from infrastructure development and renovation projects is considered to not be influenced by capita behaviour or directly relatable to population size.[2175] Importantly, this measure of per capita waste under the circular economy policy differs from that presented within the state's annual industry waste reports, which includes waste derived from all source sectors, as well as previous state of the environment reporting, which was limited to municipal per capita waste. Thus, with the aim of improving alignment between state of the environment reporting and Victoria's circular economy targets, the waste generation per capita indicator has been expanded in this report to include the C&I source sector within the calculation.[2176] Also noteworthy is that data limitations within annual waste reporting prior to 2017-18 prohibited long-term trend analyses to be undertaken for the modified definition of per capita waste generation.

Waste generation per capita in Victoria has been on a slow, but continued, rise since 2017-18, increasing from 1,188 kg total waste per person to 1,225 kg per person in 2019-20 (Figure W3). Despite the amount of recyclable material making up the greatest proportion of per capita waste annually (average 55%), the diversion rate declined each year across the 3-year period from 56% to 54%, meaning that every Victorian increasingly disposed of more waste and recycled progressively less. Waste entering landfill rose from 519 kg per person to 560 kg per person, representing an overall 8% increase between 2017-18 and 2019-20. By contrast, the amount of recovered material per person exhibited an overall 1% reduction, with recovery falling to its lowest level in 2018-19.

Underpinning this overall pattern in per capita waste generation was a discernible level of growth in the amount of garbage produced by the C&I sector (16%) as well as a sharp rise in the quantity of recyclables produced by the MSW sector (35%). By 2030, with an estimated 7.6 million Victorians, it is projected that waste per capita will be 1.1 t per person per person.[2177, 2178] This projection exceeds the state target of 1.0 t of waste per person (15% reduction from 2018-19 baseline), although it does meet the national target under the National Waste Policy and Action Plan 2019, which is to reduce per capita waste by 10%.[2179]

[2174] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Strategic summary report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Strategic-Summary-Report.pdf Accessed 30 June 2022.

[2175] Waste generation per capita in the SoE 2023 report is calculated by summing the total amount of waste generated from the MSW and C&I sectors and dividing it by state population. Annual waste figures used in these calculations is derived from the annual RIWRs. The metric in previous state of the environment reporting was calculated as total MSW waste generation divided by state population.

[2176] Australian Centre for Population 2022, 'State and territory projections', https://population.gov.au/data-and-forecasts/dashboards/state-and-territory-projections Accessed 7 October 2022.

[2177] Sustainability Victoria (SV) 2022, 'Waste projection model', Melbourne, Victoria, https://www.sustainability.vic.gov.au/research-data-and-insights/waste-data/interactive-waste-data/victorias-waste-projection-model Accessed 18 July 2022.

[2178] Department of Climate Change, Energy, the Environment and Water (DCCEEW) 2019, 'National Waste Policy Action Plan 2019', https://www.agriculture.gov.au/sites/default/files/documents/national-waste-policy-action-plan-2019.pdf Accessed 21 December 2022.

[2179] Sustainability Victoria (SV) 2019, 'Victorian recycling industry annual report 2017-18', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Recycling-Industry-Annual-Report-2017%E2%80%9318.pdf Accessed 30 June 2022.

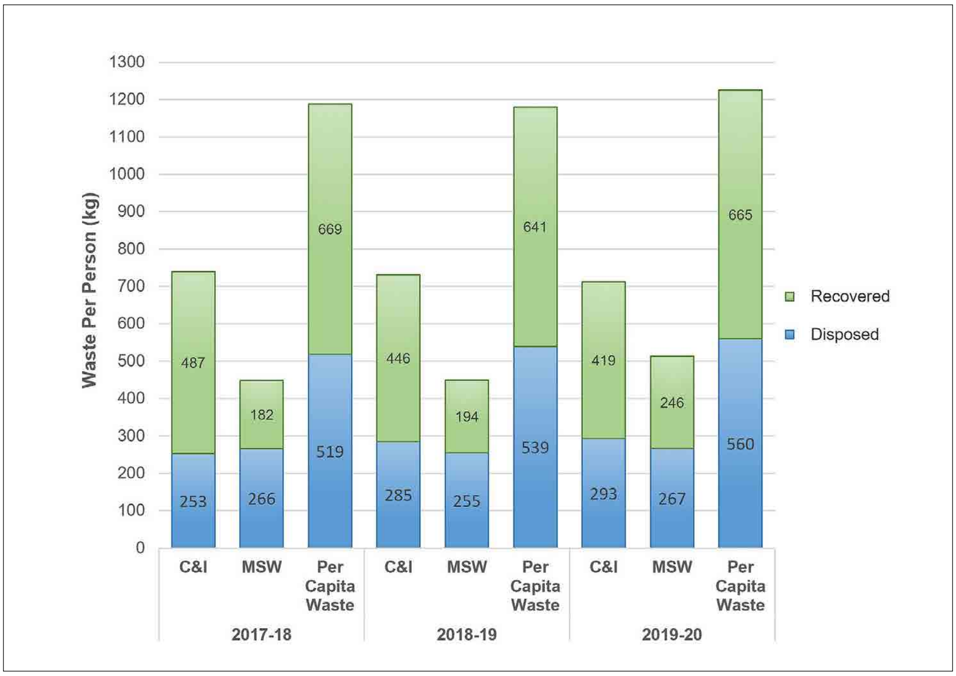

Figure W3: Total generated waste yields per capita in Victoria between 2017-18 and 2019-20.[2180, 2181, 2182]

Recycling bins in Moonee Valley, Victoria.
© Recycling Victoria.

2180. Sustainability Victoria (SV) 2020, 'Victorian recycling industry annual report 2018-19', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Recycling-Industry-Annual-Report-2018-19.pdf Accessed 30 June 2022.
2181. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Recycling industry waste report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Recycling-Industry-Report-2019-20.pdf Accessed 30 June 2022.
2182. Sustainability Victoria (SV) 2020, 'The path to half', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/asset-download/Report-The-Path-to-Half.pdf Accessed 18 July 2022.

Waste and resource recovery

Food Waste

Indicator W:03 Total food waste generation

W:03 Total food waste generation						
Regions(s)	**2023 status**	**2023 trend**	**2023 confidence**	**2018 status**	**2018 trend**	**2018 data quality**
Statewide	🔴	?	🔴	🔴	→	🟢
Data source(s):	DCCEEW, SV					
Measure(s):	Annual amounts of food waste generated (tonnes) by all source sectors					

Why this indicator?

Increasing amounts of generated food waste entering landfill have significant social, economic and environmental impacts in terms of leachates, emission of GHGs, lost natural resources and economic costs, and also contribute to food insecurity.

Criteria used for status assessment

Good: Achieving Victoria's target of halving food waste from the 2018–19 baseline by 2030 (based on waste projection models)

Fair: Achieving within 5% of Victoria's target of halving food waste from the 2018–19 baseline (45%–49%) by 2030 (based on waste projection models)

Poor: Achieving less than 45% reduction in Victoria's food waste from the 2018–19 baseline by 2030 (based on waste projection models)

Why this assessment in 2023?

Based on the limited data available, the amount of food waste generated and recovered (biomass, composting) has been decreasing overall in Victoria from 2006–07 to 2018–19 (most recent data). Reductions in food waste generation were also observed within the SoE 2018 reporting period. However, during the SoE 2023 reporting period, the amount of food waste being produced and disposed of has been increasing overall, by 5% and 12% respectively, while recovery decreased by 5%. Decreasing diversion rates, coupled with increasing levels of disposal, has meant food waste continues to represent a dominant waste stream entering landfill. This was particularly evident during 2018–19, where 16% of the state's total disposed waste was composed of food material.

While the MSW sector was the major contributor to the state's total generated food waste, due in large part to the combined effects of preparing too much food and misunderstanding of food labelling, much of the recent increase in generation and landfilling of food waste was driven by the C&I sector, particularly food retailers and hospitality businesses. Limited access to recycling collection services was cited as the primary factor for weak recovery among segments of this source sector. This limitation extends to the MSW sector as well, resulting in high contamination levels and low-quality recycled material, although reforms to household recycling services are working to improve food waste recovery within the MSW sector.

Data confidence was rated as low, particularly due to the exclusion of food waste generated on farms and in many food processing operations, and other limitations on data availability.

Summary of State of the Environment 2018 Report assessment

- Food waste remained relatively stable at 1.2 Mt from 2013-14 to 2015-16 then declined slightly to 1.1 Mt during 2016-17, noting that data on food waste was not available for 2012-13.
- Disposal of food waste increased overall by 14%, from 661 Kt in 2013-14 to 754 Kt in 2016-17, while recovery declined by 34%. On average, food waste made up 17% of all waste entering landfill annually.
- The MSW sector was the highest contributing source sector of food waste across years, making upwards of 67% of total food waste in the state most of which was disposed of in landfill (58% - 68%).

Waste and resource recovery

Critical data used for the 2023 assessment

- National Waste Database 2020

2023 assessment

As a major producer and processor of Australian food, Victoria is also responsible for generating approximately a quarter of the country's food waste, with nearly two thirds of this being avoidable.[2183, 2184] It is estimated that food waste costs Victoria upwards of $6 billion annually, while also imposing environmental costs, such as the loss of around 31 GL of water and the generation of around 15% of the state's non-energy greenhouse gas emissions.[2185]

To address the issue of food waste, the Victorian Government has committed to halving food waste by 2030 as part of the National Food Strategy, which will also contribute towards achieving the state's circular economy target of halving organic waste entering landfill by 2030.[2186]

Based on the limited national data (2018-19 is most recent), the total amount of food waste generated in Victoria has fluctuated considerably year-to-year but has been on an overall decline (13%), decreasing from 1.3 Mt in 2006-07 to 1.1 Mt in 2018-19 (Figure W4). Disposal of food also saw a significant overall reduction (33%) across the 13-year period. Since 2017-18, however, Victoria saw rises in both food waste generation (5%) and the amount of food entering landfill (12%). Recovery of food waste, by contrast, declined by 5%. What's more, food waste had continued to represent a dominant waste stream entering landfill each year. In 2018-19, food waste contributed 16% of all waste entering landfill, up from 14% in the previous year.

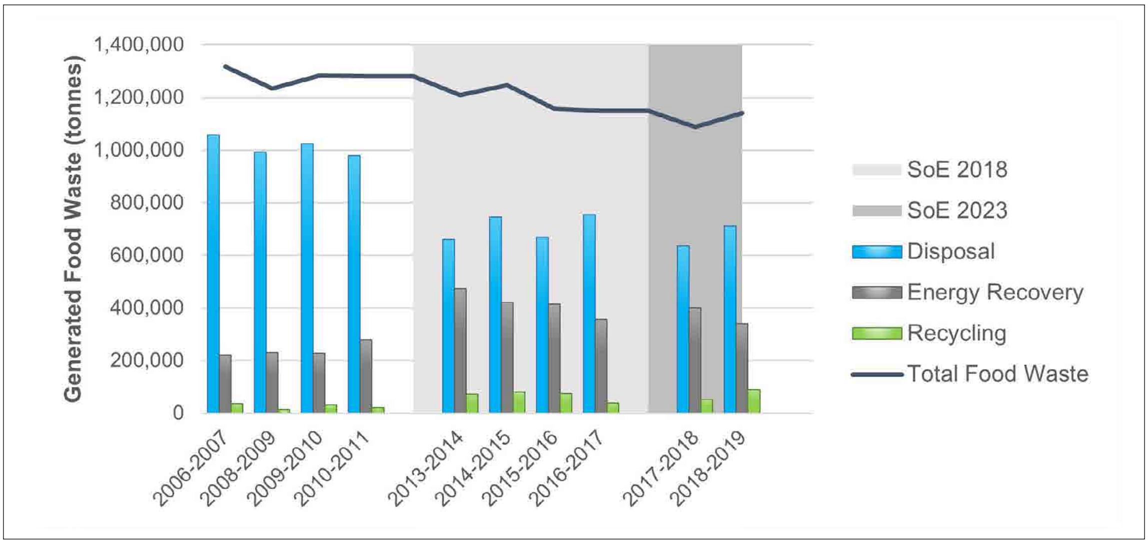

Figure W4: Total food waste generation and destination in Victoria from 2006-07 and 2018-19.[2187] Light and dark grey time series represent the SoE 2018 and SoE 2023 reporting periods, respectively. Note: Data for the years 2007-08, 2011-12, and 2012-13 were not available.

2183. Infrastructure Victoria (IV) 2020, 'Advice on recycling and resource recovery infrastructure', Melbourne, Victoria, https://www.infrastructurevictoria.com.au/wp-content/uploads/2020/03/Advice-on-recycling-and-resource-recovery-FINAL-REPORT.pdf Accessed 29 July 2022.
2184. Sustainability Victoria (SV) 2020, 'The path to half', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/asset-download/Report-The-Path-to-Half.pdf Accessed 18 July 2022.
2185. Ibid
2186. Blue Environment 2020, 'National waste database 2020', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-database-2020.xlsx Accessed 5 July 2022.
2187. Sustainability Victoria (SV) 2013, 'Victorian statewide garbage bin audit 2013 - food waste', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Statewide-Garbage-Bin-Audit-2013.pdf Accessed 17 August 2022.

To understand the factors underpinning food waste patterns in the state, it is important to examine the sources of food waste. Most of Victoria's generated food waste occurred at the later stages of the supply chain, where the MSW sector was by far the largest source of generated food waste despite an overall decline since 2006-07 (Figure W5). Since 2017-18, food waste generated by households has been on falling, although the proportion of this waste entering landfill rose from 62% to 70%. Garbage bin audits revealed that households threw away an estimated 3.4 kg (35% of bins) of food each week, much of which was considered edible.[2188] The most commonly discarded food types were bakery items, meals, dairy/eggs, and fresh fruit and vegetables.[2189] The primary cause for the disposal of edible food was too much food being prepared for meals, particularly among households with children, although a lack of understanding of food labelling and uncertainty around appropriate storage of leftover food were also cited as being other contributing factors for the disposal of avoidable food waste in the home.[2190]

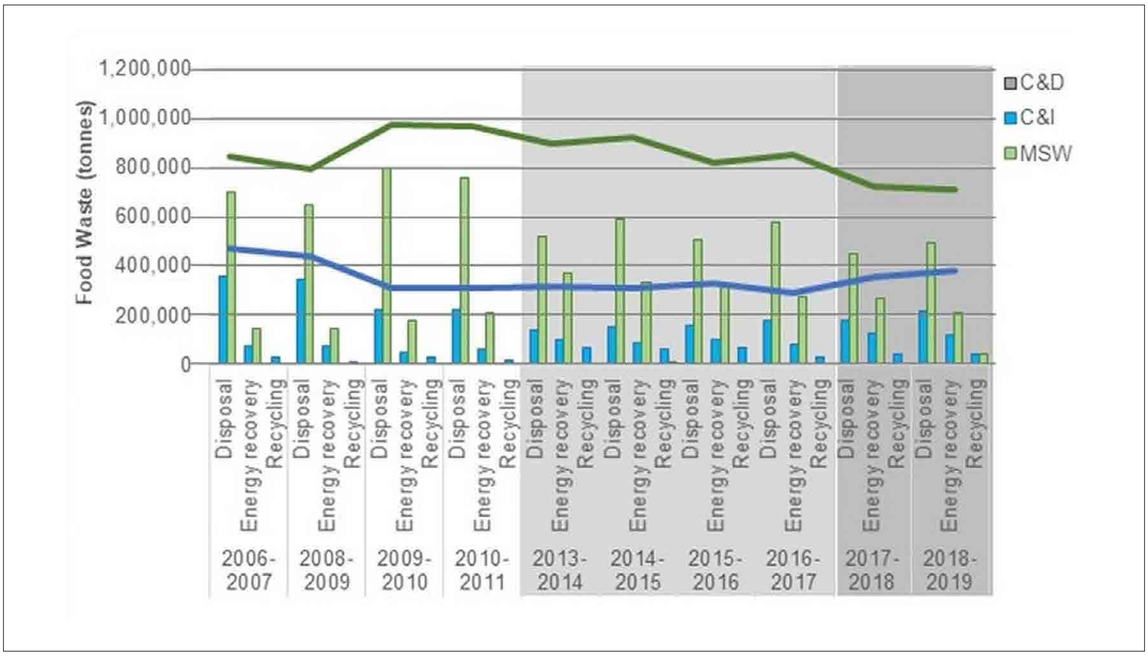

Figure W5: Total generation and destination of food waste by source sector in Victoria between 2006-07 and 2018-19.[2191]

The other significant contributor of food waste in Victoria was from the C&I sector, albeit to a lesser degree than that of the MSW sector (Figure W5). Overall, manufacturers, food retailers and hospitality businesses contributed an average of 29% of the state's total food waste generation and 26% of all food waste entering landfill over the 13-year period. The level of contribution by this sector remained relatively stable between 2009-10 and 2016-17, following a short period of decline. By 2017-18, however, growth in the food service and hospitality industry, coupled with rising levels of food manufacturing to meet the demands of a growing population, prompted a marked increase in both generated food waste as well as the amount entering landfill. Food waste generation rose to 382 Kt, with more than half being disposed of (493 Kt).

[2188] Sustainability Victoria (SV) 2013, 'Victorian statewide garbage bin audit 2013 - food waste', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Statewide-Garbage-Bin-Audit-2013.pdf Accessed 17 August 2022.

[2189] Fight Food Waste Cooperative Research Centre 2019, 'Food waste Australian household attitudes and behaviours: National benchmarking study', Adelaide, South Australia, https://fightfoodwastecrc.com.au/wp-content/uploads/2019/11/Summary-Report_final.pdf Accessed 17 August 2022.

[2190] Blue Environment 2020, 'National waste database 2020', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-database-2020.xlsx Accessed 5 July 2022.

[2191] Diversion rate is calculated by dividing the amount of recovered material by total waste generation. Material recovery and generated waste figures used in the calculations are derived from the annual RIWRs.

Waste and resource recovery

Despite positive overall trends (2006-07 to 2018-19), food waste generation in Victoria has been on the rise in recent years while the recovery rate has fallen from 42% in 2017-18 to 38% in 2018-19, meaning that a greater proportion food waste was sent to landfill. Whether this trend will enable Victoria to meet the national target of halving food waste by 2030 is unclear, as the SV waste projection model only provides projections for the organics waste stream as a whole, as opposed to its constituent waste types, which includes food. Nevertheless, if it is assumed that the proportion of food waste making up the organics waste stream remains the same as that from the 2018-19 baseline (36%), then the projected food waste in 2030 is predicted to be 1.1 Mt, which exceeds the state target of 570 Kt.

Waste Recycling

Indicator W:04 Diversion rate

W:04 Diversion rate

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴	→	🔴	🟡	→	🟢
Data source(s):	SV					
Measure(s):	Percentage of generated non-hazardous waste that is diverted from landfill					

Why this indicator?

Diversion rate is a measure of how much generated waste is diverted from landfill with the intention of recycling or reuse. This metric serves as an important benchmark for assessing the effectiveness of the state's recycling program and tracking progress towards the transition to a circular economy.

Criteria used for status assessment

Good: Achieving Victoria's target of diverting 80% of waste from landfill by 2030 (based on waste projection models)

Fair: Achieving within 5% of Victoria's target of diverting waste from landfill (75%–79%) by 2030 (based on waste projection models)

Poor: Achieving less than 75% diversion of waste from landfill by 2030 (based on waste projection models)

Why this assessment in 2023?

The diversion rate increased overall by 10% between 2010–11 and 2019–20, and reached its highest level of 70% during 2018–19 and 2019–20. When comparing the trend between the SoE 2018 Report and the SoE 2023 Report, the diversion rate increased at an overall similar level of 1% for the 5-year period.

Since 2017–18, the proportion of waste diverted from landfill has remained stable, increasing by 1%, while the rate at which waste is generated increased by 10%. This means that more waste has been entering landfill each year, with much of this disposed material being recoverable.

The materials with the strongest diversion rates in 2019–20 included metals, aggregates, masonry and soil, and glass, while the diversion of plastics from landfill remained low. Unlike in previous years, the majority (90%) of recovered material was reprocessed within Victoria, leading to a recycling rate of 67%, up from 65% in 2018–19. A number of external factors that severely impacted Victoria's waste and resource recovery sector between 2018 and 2021 contributed to the deterioration, or lack of progress, of waste diversion. At the start of January 2018, China began to stringently enforce restrictions on the importation of recycled materials under its National Sword policy, which effectively removed a key international market for trading sorted recyclables. This has created volatility in global and domestic pricing for recovered materials. With limited export destinations available, the vulnerabilities within Victoria's waste and resource recovery sector were exposed. As a result, excessive stockpiling of combustible materials and the landfilling of household recyclables increased.

With stagnating diversion rates and increasing amounts of waste being landfilled, including recyclable materials, the waste projection model indicates that Victoria will not achieve its target of diverting 80% of waste from landfill by 2030.

Waste and resource recovery

Summary of State of the Environment 2018 Report assessment

- Diversion rate in Victoria remained relatively stable during 2012-13 to 2016-17, ranging from 66% to 67%.
- Resource recovery and waste generation both had similar levels of growth (7%), while the amount of waste being disposed rose slightly less at 6%.
- Among the different waste streams, aggregates had the highest level of recovery in 2016-17, while rubber, plastics, and glass had the lowest recovery. Recovery of organics had the largest level of growth (80%) than any other waste stream, while glass, by contrast, was the only type of waste showing a reduced level of recovery relative to 2015-16. However, without data on total waste generation or recovery rate for each waste stream, it is unclear as to what the diversion rates were for individual waste types.
- In 2016-17, the C&D sector was the greatest contributor to resource recovery (49%), while the MSW was the lowest contributing sector (15%), likely due to higher levels of contamination among household recyclables. Comparisons in diversion rates across source sectors, however, could not be performed as no data on total waste generation for each source sector was available.

Critical data used for the 2023 assessment

- Waste Projection Model 2022 Dashboard
- Waste and Recycling in Victoria – Recycling Industry Workbook 2019-20
- Waste and Recycling in Victoria - Local Government Waste Services Workbook 2019–20

2023 assessment

Victoria's waste reporting currently evaluates resource recovery in terms of the diversion rate. Diversion rate is defined as the proportion of generated waste material that is recovered and enters the waste management system with the intent for reprocessing or reuse.[2192] Importantly, the diversion rate is not a measure of recycling performance per se in that the amount of recovered material which is used in determining diversion rate includes both the material that is recycled as well as the material which is recovered but is not reprocessed due to contamination, processing losses or being exported but disposed of within the receiving country. Thus, the diversion rate can in effect be misleading in that it does not represent the amount of material that is recycled, nor is it a true indication of how much waste is actually diverted from landfill due to the unknown fate of exported material. Adding to this is the fact that the weight of the recyclable material influences the calculation of diversion rate, skewing it up if the recyclables are heavy (e.g. glass), or down if they are light (e.g. plastic). Reporting the recycling rate as a complementary metric, and measuring waste in terms of volume as opposed to weight, would serve to address these issues. Nevertheless, the diversion rate as reported within the state's annual waste reports does afford some valuable information in terms of how well the least desired outcome on the waste hierarchy (landfilling) is avoided locally. This information can then be used to evaluate the efficacy of waste reduction policies and initiatives, as well as to measure progress towards transitioning to a circular economy. Accordingly, the Victorian Government has established a target for waste diversion under its state's circular economy policy, which is to divert 80% of the state's total generated waste from landfill by 2030.

Over the last 10 years (2010-11 to 2019-20), resource recovery in Victoria has demonstrated strong growth, increasing overall by 37% (Figure W6). Yet, even with this positive long-term trend in material recovery, the proportion of waste being diverted from landfill has had only a small degree of growth by comparison (10% overall), which has led to more waste being disposed each year. This pattern was especially prominent in more recent years where both resource recovery and waste generation had marked growth from 2016-17 to 2017-18 (16% and 12%, respectively) which continued, albeit to a lesser extent, across the SoE 2023 reporting period until reaching their highest levels by 2019-20. The reported diversion rate,

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[2192] Victorian Auditor-General's Office (VAGO) 2019, 'Recovering and reprocessing resources from waste: Independent assurance report to Parliament', Melbourne, Victoria, https://www.audit.vic.gov.au/node/33226 Accessed 28 July 2022.

by contrast, remained relatively unchanged (>1%) during this period, ranging between 69% and 70%. But, if a more conservative approach to estimating Victoria's diversion rate is taken, where the amount of recovered material that was exported is excluded due to its unknown fate, the proportion of waste diverted from landfill would instead be between 61% to 63% from 2017-18 and 2019-20. With this observed stagnancy in diversion rate over the SoE 2023 reporting period, coupled with rising waste generation, 2019-20 saw the most waste being lost to landfill than in any other year since 2010-11. What's more, much of the disposed waste could have been recovered for reuse or recycling, highlighting an opportunity missed for maximizing waste reduction in the state.[2193]

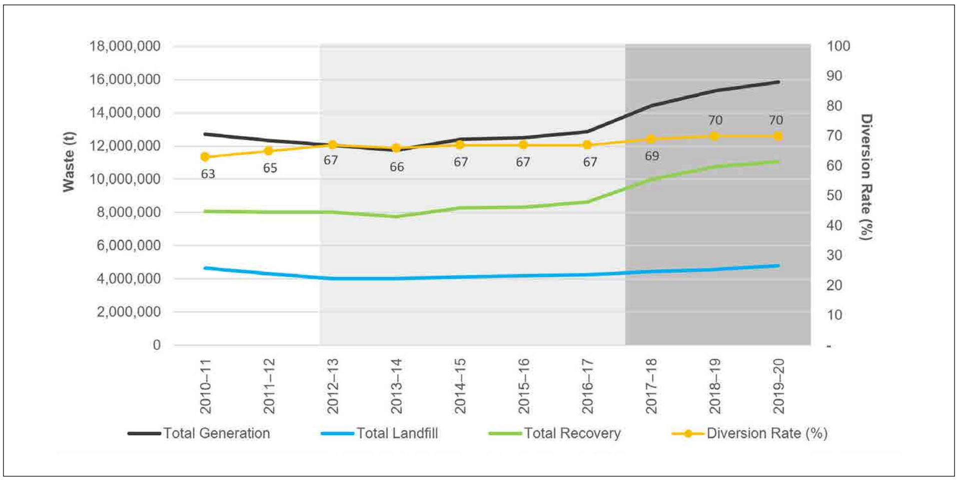

Figure W6: Comparison of trends between the total amount of waste that is generated, disposed and diverted from landfill in Victoria during 2010-11 to 2019-20.[2194] Light and dark grey time series represents the SoE 2018 and SoE 2023 reporting periods, respectively.

The materials with the strongest diversion rates in Victoria during 2019-20 included metals (91%), aggregates, masonry and soil (85%), and glass (78%), while diversion of plastics from landfill remained low (22%). Low diversion of plastic waste material was further reflected on the national level as well, where it was reported that only 16% of plastics were recovered in Australia in 2019-20, far below the national target for recovering 70% of plastics.[2195] Importantly, much of the recovered material is now reprocessed within Victoria and serves as feedstock for the fabrication of a range of recycled products used in transport and stormwater drainage infrastructure, building construction, outdoor recreational equipment, and packaging. In 2019-20, for example, 93% (14.8 Mt) of all recyclables were reprocessed locally, up from 90% (9.6 Mt) the previous year. Plastics demonstrated the largest increase in domestic reprocessing, with the proportion of recovered material remaining in Victoria for reprocessing rising by 6%.

Nevertheless, the predominance for onshore management of recycled material has not always been the case. Historically, Victoria has had a heavy reliance on export markets for secondary reprocessing and manufacturing, particularly for materials arising from household collections.[2196, 2197] The shift in trend towards local reprocessing in recent years was due in part by greater processing capacity in the state, but the largest driver was

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2193. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria – recycling industry workbook 2019-20', Melbourne, Victoria, https://www.audit.vic.gov.au/report/recovering-and-reprocessing-resources-waste?section= Accessed 5 July 2022.
2194. Australian Packaging Covenant Organisation (APCO) 2021, 'APCO collective impact report' Sydney, New South Wales, https://documents.packagingcovenant.org.au/public-documents/APCO%20Collective%20Impact%20Report Accessed 30 February 2023.
2195. Sustainability Victoria (SV) 2020, 'Victorian recycling industry annual report 2018-19', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Recycling-Industry-Annual-Report-2018-19.pdf Accessed 30 June 2022.
2196. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Strategic summary report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Strategic-Summary-Report.pdf Accessed 30 June 2022.
2197. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.

China's aggressive enforcement of its 2017 National Sword policy in 2018; which was then enforced by other export destination countries.[2198] This policy bans the importation of 24 types of solid waste, as well as placing strict contamination limits on accepted recyclable material. Notably, the National Sword policy followed on from China's announcement in 2013 of a similar policy, Green Fence, which largely went ignored by the Victorian Government in that no analysis of impacts or preparatory actions were taken.[2199] It can be speculated then that, had proper recognition of potential implications and mitigative action been undertaken in response to the 2013 policy, the recycling crisis in the state that followed the strict enforcement of China's National Sword policy may have been less severe, or perhaps, even circumvented altogether.

Many Victorian material recovery facilities, however, were unable to meet the strict contamination standards applied by the importing countries under the National Sword policy, which meant they were no longer able to rely on the international commodities markets to take recovered material as they once did. With limited ability to export, coupled with inadequate capacity to manage the state's volume of materials locally, excessive stockpiling of combustible waste materials ensued, posing a great threat to the health and safety of Victoria's communities and environment.[2200, 2201] These impacts were illustrated by the forced closure of Victoria's largest material recovery facility, SKM, in early 2019 following a large fire which erupted as a result of dangerous levels of stockpiling. The fire lasted for several days and caused severe health and environmental impacts, including the release of high levels of $PM_{2.5}$ into the air and oil runoff and leachate entering the environment, while also imposing a profound financial cost to the state in excess of $111 million.[2202]

In response to the SKM incident, the Victorian Government used the powers under the interim waste management policy, Waste Management Policy (Combustible Recyclable and Waste Material) to establish the Resource Recovery Facilities Audit Taskforce in 2017. The taskforce conducted audits of facilities across Victoria and identified a number of systemic management issues, including oversized stockpiles of combustible waste material, absent or ineffective emergency response procedures and equipment, and operational issues.[2203] Collectively, these issues led the taskforce to conclude that the resource recovery sector was generally poorly prepared and ill equipped to manage fire risks.[2204] This conclusion was further substantiated by the fact that the frequency and severity of fires at resource recovery facilities had increased between 2008 and 2017.[2205] Another key outcome of the taskforce was the development of supporting guidelines to the interim waste management policy (Management and Storage of Combustible Recyclable and Waste Materials – Guideline), which required compliance by facilities undertaking stockpiling and storage of waste materials.[2206]

As SKM serviced half of the Victorian local governments, the councils affected by its closure had no other option but to send an estimated 50 to 70 Kt of potentially recyclable material to landfill and place an additional 280 Kt of household recyclables into storage with the intent of reprocessing in the future, a practice that was sustained prior to and during this period.[2207, 2208] By mid-2020, all of the stored recyclable material was reported as cleared, with most being unrecovered and instead sent to landfill.[2209] What's more, the closure of the SKM specifically, and the enforcement of China's National Sword policy more broadly, had caused a rise (22%) in the costs to local governments for providing household recycling collection services, as they were now needing to pay

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[2198] Legislative Council Environment and Planning Committee Parliament of Victoria 2019, 'Inquiry into recycling and waste management', Melbourne, Victoria, https://www.parliament.vic.gov.au/file_uploads/LCEPC_59-02_Inquiry_into_recycling_and_waste_management__6hNrvBj7.pdf Accessed 28 July 2022.

[2199] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.

[2200] Legislative Council Environment and Planning Committee Parliament of Victoria 2019, 'Inquiry into recycling and waste management', Melbourne, Victoria, https://www.parliament.vic.gov.au/file_uploads/LCEPC_59-02_Inquiry_into_recycling_and_waste_management__6hNrvBj7.pdf Accessed 28 July 2022.

[2201] Department of Environment, Land, Water and Planning (DELWP) 2018, 'Management and storage of combustible recyclable and waste material', Melbourne, Victoria, https://www.vic.gov.au/sites/default/files/2019-10/Combustible-Recyclable-and-Waste-Material-PIA-PDF.pdf Accessed 23 January 2023.

[2202] Department of Environment, Land, Water and Planning (DELWP) 2018, 'Management and storage of combustible recyclable and waste material', Melbourne, Victoria, https://www.vic.gov.au/sites/default/files/2019-10/Combustible-Recyclable-and-Waste-Material-PIA-PDF.pdf Accessed 23 January 2023.

[2203] Ibid.

[2204] Ibid.

[2205] Ibid.

[2206] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.

[2207] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Strategic summary report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Strategic-Summary-Report.pdf Accessed 30 June 2022.

[2208] Envisage Works 2020, 'Recovered resources market bulletin November: Victorian market intelligence project (edition # 16)', Report prepared for Sustainability Victoria (SV) and the Waste Management and Resource Recovery Association of Australia, https://assets.sustainability.vic.gov.au/susvic/Report-Recovered-Resources-Market-Bulletin-November-2020.pdf Accessed on 12 August 2022

[2209] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.

for this service, where previously councils would have instead received payment by contractors through the on-selling of household recyclables to export markets.[2210] Local governments dedicated nearly $150 million in 2019-20 towards the provision of recycling services to their communities, up from $121 million in the previous year, with this cost concerningly exceeding that of the garbage collection service. This spike in expenditure was particularly felt by the local governments directly affected by the SKM closure, which saw them paying an estimated $64 per tonne of collected recyclables which equated to a net income loss of approximately $130 per tonne.[2211] As of late 2021, however, growth in the state's reprocessing capacity and strengthening of its low end-markets served to ease the pressures prompted by China's National Sword policy and subsequent collapse of the SKM material recovery facility, enabling the rate of stockpiling and disposal of recyclable materials to return to more normal levels.[2212]

It was expected that local governments and the resource recovery sector would have been provided support to help alleviate the impacts arising from the drastic, albeit forewarned, import restrictions by allocating proceeds from the Victoria's Sustainability Fund to provide immediate relief to councils as well as to accelerate the development of a resilient resource recovery sector capable of managing recyclable waste material within the state. However, only a small proportion of the funds were used during 2018 to tackle the recycling crisis, marking an opportunity missed to easily prevent, or at least minimise, the occurrence of stockpiling and landfilling of municipal recyclables and rapidly grow the state's recycling sector.[2213] This had prompted much scrutiny over the management of the Sustainability Fund, including an investigation by the Victorian Auditor-General's Office, where it was argued that the pool of money funded by landfill levies and tip fees, and whose purpose is to address current issues in waste management and resource recovery as well as promote environmentally sustainable uses of resources and best practices in waste management, had been consistently underspent, even in the wake of significant crises, and had not been dedicated to the intended purposes under the EP Act.[2214] According the Sustainability Fund 2018-19 Report, $59.3 million of the $511 million available funds were invested in waste and resource recovery projects and activities.[2215] This is in stark contrast to the $143.2 dedicated to other state priorities.

The flow-on effects of the SKM closure are reflected within the reported recovery patterns among MSW sector, where in 2018-19 the diversion rate declined from 44% to 43% as recyclable material was placed into storage (Figure W7). By 2019-20, with the clearance and ultimate landfilling of hundreds of kilo-tonnes of stored recyclable material to landfill, household waste disposal rose from 1.7 Mt to 1.8 Mt.[2216] Surprisingly, despite an estimated increase of 100 - 167% in the amount of potentially recyclable material being lost to landfill, the recovery-related impacts spurred by the closure of the SKM facility was somewhat offset by the effects of yet another significant challenge that confronted Victoria's waste and resource recovery sector, the COVID-19 pandemic.[2217, 2218] As extensive COVID-19 stay-at-home orders caused dramatic reductions in business operations, local governments were faced with having to unexpectedly adapt to the Victorian Government's response to the pandemic and manage the large volumes of generated waste that was shifted out of the C&I sector and concentrated to within the MSW sector.[2219] Indeed, in 2019-20, household waste generation increased by 16% (3.0 Mt

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[2210] Parliamentary Budget Office 2019, 'Councils recycling costs', https://pbo.vic.gov.au/response/527 Accessed 17 February 2023.

[2211] Envisage Works 2022, 'Recovered resources market bulletin February: Victorian market intelligence project (edition # 19)', Report prepared for Sustainability Victoria (SV) and the Waste Management and Resource Recovery Association of Australia, https://assets.sustainability.vic.gov.au/susvic/Recovered-Resources-Market-Bulletin-February-2022.pdf.pdf Accessed 12 August 2022.

[2212] Debbie Cuthbertson 2018, 'Open up your wallet: The Sustainability Fund could save the recycling system', The Age, https://www.theage.com.au/national/victoria/open-up-your-wallet-sustainability-fund-could-save-recycling-system-20180201-p4yz7y.html Accessed 17 February 2023.

[2213] Victorian Auditor-General's Office (VAGO) 2019, Managing the municipal and industrial landfill levy', Melbourne, Victoria, https://www.audit.vic.gov.au/report/managing-municipal-and-industrial-landfill-levy?section= Accessed 17 February 2023.

[2214] Department of Environment, Land, Water and Planning (DELWP) 2021, 'Sustainability fund activities report 2018-19', Melbourne, Victoria, https://www.environment.vic.gov.au/__data/assets/pdf_file/0037/487873/FINAL-DELWP0112_SustainabilityFundReport2018_19_v24.pdf Accessed 17 February 2023.

[2215] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Recycling industry waste report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Recycling-Industry-Report-2019-20.pdf Accessed 30 June 2022.

[2216] Ibid.

[2217] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria - local government waste services workbook 2019–20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Workbook-Waste-Local-Government-Waste-Services-Workbook-2019-20.xlsx Accessed 4 July 2022.

[2218] Ibid

[2219] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Recycling industry waste report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Recycling-Industry-Report-2019-20.pdf Accessed 30 June 2022.

to 3.4 Mt), while recovery rose to a record high of 29% (1.3 Mt to 1.7 Mt), prompting the sector's diversion rate to also grow to reach 48%. During this same period, the C&I sector saw concurrent reductions in both the amount of waste that was generated (4.8 Mt to 4.7 Mt) and diverted (61% to 59%).[2220]

Reforms to household recycling services, as part of the circular economy policy, was also thought to have played a role towards the recent rise in household diversion rates.[2221] The key aim of transitioning to a standardized 4-stream recycling system is to maximize recovery among households by reducing contamination-related losses of potentially recyclable materials and improve the quality of recycled products for reuse, both of which are issues common to conventional co-mingled collection systems. In the years prior to the reforms, an average of 18% of material collected from household recycling bins was lost annually to landfill.[2222] Among these losses was approximately 11% of recyclable materials that were unrecoverable due to contamination post-sorting or being of low value, while the remaining 7% was gross contamination which occurs from improper disposal of non-recyclable waste.[2223] By 2019-20, greater availability of FOGO and dedicated glass collection services seemingly resulted in the expected improvement in resource recovery. This was evidenced by increases in the amounts of both glass and organic waste material recovered among the MSW sector during this period.[2224, 2225] However, gross contamination levels also increased to 10% in 2020 and remained at this level in 2021, making it unclear as to whether the ongoing reforms to household recycling services had actually contributed to the observed increase in the state's diversion rate given the rise in inappropriate sorting of waste materials.[2226, 2227, 2228] It should also be noted that the gross contamination rates reported within the Recovered Resources Market Bulletin Report were lower than those presented within the LGWSR, which stated it as being 13% during 2019-20, up from 11% in the previous year, although these data were compromised by the impacts of the SKM closure.[2229] More reliable and ongoing data is needed to better evaluate how effective household recycling systems reforms, as well as the future introduction of the container deposit scheme, are in alleviating the issue of contamination and moving Victoria towards its circular economy target of diverting 80% of waste from landfill. Similarly, data on contamination levels among the C&I and C&D are lacking, as these sectors generally follow different recovery pathways that are less reliant on material recovery facilities. However, this information would serve in supporting a greater understanding of contamination-related losses among these source sectors.

Unlike the MSW and C&I sectors, who saw relatively low diversion rates, the C&D had continued to maintain the highest levels of waste diversion among all source sectors (Figure W7). Since 2017-18, the percentage of waste materials diverted from landfill ranged from 84% to 87%, with peak recovery occurring in 2018-19. Aggregates continued to be recovered at high rates within the C&D sector, while the diversion of other materials, such as glass and plastics, had risen more slowly. Increasing reliance on recycled materials for infrastructure projects had contributed to much of the growth in material recovery by the C&D sector.[2230] This construction

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2220. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.
2221. Envisage Works 2021, 'Recovered resources market bulletin March: Victorian market intelligence project (edition # 17)', Report prepared for Sustainability Victoria (SV) and the Waste Management and Resource Recovery Association of Australia, https://assets.sustainability.vic.gov.au/susvic/Recovered-Resources-Market-Bulletin-March-2021.pdf Accessed 12 August 2022.
2222. Gross contamination is defined by Sustainability Victoria as the amount of incorrect material placed in the kerbside bin that cannot be recovered or sorted for reprocessing.
2223. Sustainability Victoria (SV) 2019, 'Victorian local government waste services report 2017-18', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Local-Government-Annual-Waste-Services-Report-2017-18.pdf Accessed 4 July 2022.
2224. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.
2225. Envisage Works 2021, 'Recovered resources market bulletin March: Victorian market intelligence project (edition # 17)', Report prepared for Sustainability Victoria (SV) and the Waste Management and Resource Recovery Association of Australia, https://assets.sustainability.vic.gov.au/susvic/Recovered-Resources-Market-Bulletin-March-2021.pdf Accessed 12 August 2022.
2226. Envisage Works 2021, 'Recovered resources market bulletin July: Victorian market intelligence project (edition # 18)', Report prepared for Sustainability Victoria (SV) and the Waste Management and Resource Recovery Association of Australia, https://assets.sustainability.vic.gov.au/susvic/Recovered-Resources-Market-Bulletin-July-2021.pdf Accessed 12 August 2022.
2227. Envisage Works 2022, 'Recovered resources market bulletin February: Victorian market intelligence project (edition # 19)', Report prepared for Sustainability Victoria (SV) and the Waste Management and Resource Recovery Association of Australia, https://assets.sustainability.vic.gov.au/susvic/Recovered-Resources-Market-Bulletin-February-2022.pdf.pdf Accessed 12 August 2022.
2228. Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.
2229. Sustainability Victoria (SV) 2020, 'Victorian recycling industry annual report 2018-19', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Recycling-Industry-Annual-Report-2018-19.pdf Accessed 30 June 2022.
2230. Ecologiq 2020, 'Recycled first policy' Victoria, https://bigbuild.vic.gov.au/__data/assets/pdf_file/0008/702863/Recycled-First-Policy.pdf Accessed 13 September 2022.

practice was later standardized in 2020 under the Recycled First policy which mandates organisations delivering major transport projects to prioritise the use of recycled and reused materials over virgin materials.[2231] Not only does the Recycled First policy aim to further drive the sustainable use of resources within the C&D sector, but it also aims to promote innovation in the application and quality of recycled materials as well. The trial of recycled plastic sleepers in the Wyndham Vale Stabling Yard and Richmond Station, and the erection of highway noise walls constructed of recycled plastics along the Mordialloc Freeway, are but a few examples of infrastructure projects using recycled materials in innovative ways in Victoria.

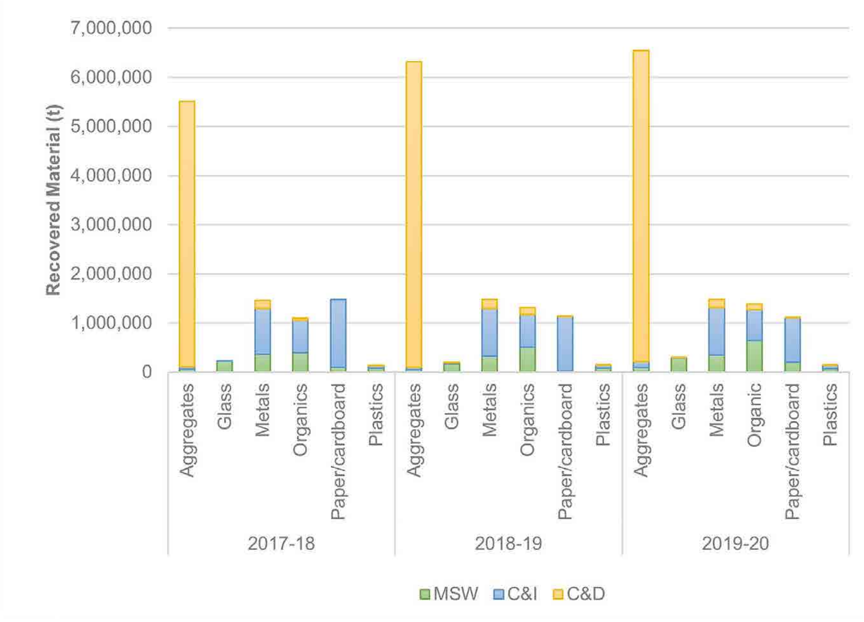


Figure W7: Total amount of material recovered for each of the major waste streams by source sector in Victoria between 2017-18 and 2019-20.[2232] Totals for rubber and textiles were excluded due to the small volumes that were recovered.

With the stagnation in the state's diversion rate between 2017-18 and 2019-20, coupled with rising waste generation, it is predicted that Victoria's diversion rate will be 71% in 2030, falling short of meeting its target under the state's circular economy policy.[2233] The actual trajectory of waste diversion may, however, shift depending upon the efficacy of ongoing and future Government policies and initiatives which aim to improve resource recovery in the state, including the household recycling system reforms, container deposit scheme, waste to energy framework, single-use plastic ban, and behaviour change campaigns.

[2231] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria – recycling industry workbook 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Workbook-Waste-Recycling-Industry-Workbook-2019%E2%80%9320.xlsx Accessed 5 July 2022.

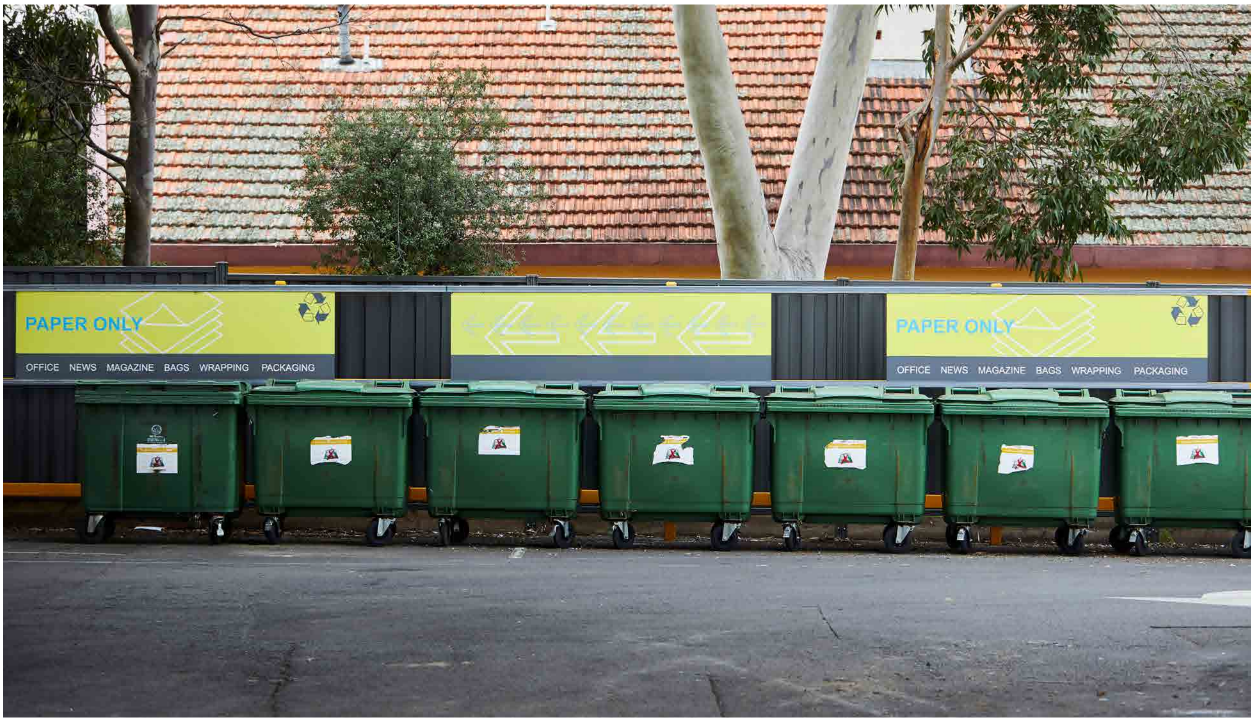
[2232] Sustainability Victoria (SV) 2022, 'Waste projection model', Melbourne, Victoria, https://www.sustainability.vic.gov.au/research-data-and-insights/waste-data/interactive-waste-data/victorias-waste-projection-model Accessed 18 July 2022

[2233] Recycling rate was calculated as the proportion of total waste generated that were reprocessed. Data were derived from RIWRs.

Waste and resource recovery

Recycling Rate

As a complimentary metric to diversion rate, trends in the recycling rate were also evaluated as a way of providing a more comprehensive picture of resource recovery in the state. Recycling rate is not explicitly presented within the state's annual reporting, however, this metric was able to be calculated using the data contained within the reports, noting that data limitations restricted calculations of recycling rates for each waste stream to only 2018-19 and 2019-20.[2234] Based on these analyses, it was found that the recycling rate in Victoria followed an upward trend between 2015-16 and 2019-20, where the proportion of waste material that was reprocessed rose steadily from 58% to 63%.[2235, 2236, 2237] This equates to 87% to 90% of recovered resources being reprocessed. The strongest performance in recycling was demonstrated in 2019-20, where 10.0 Mt of the 15.9 Mt of recovered material was manufactured into new recycled products. Among waste streams, aggregates, masonry and soils had the greatest level of recycling while plastics, by contrast, had the lowest recycling rate. In 2019-20, as an example, only 14% of plastic material was reprocessed, down from 24% in the previous year, while 78% (5 Kt) of generated plastic waste was lost to landfill.



Waste and recycling bins.
© Recycling Victoria.

[2234] Sustainability Victoria (SV) 2019, 'Victorian recycling industry annual report 2017-18', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Recycling-Industry-Annual-Report-2017%E2%80%9318.pdf Accessed 30 June 2022.

[2235] Sustainability Victoria (SV) 2020, 'Victorian recycling industry annual report 2018-19', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Recycling-Industry-Annual-Report-2018-19.pdf Accessed 30 June 2022.

[2236] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Recycling industry waste report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Recycling-Industry-Report-2019-20.pdf Accessed 30 June 2022.

[2237] Keep Australia Beautiful (KAB) 2019, 'National litter index 2018-2019: Victoria results', Newtown, New South Wales, https://assets.sustainability.vic.gov.au/susvic/Report-National-Litter-Index-2018-19-Victoria-results.pdf Accessed 14 July 2022.

Waste and resource recovery

Litter Waste

Indicator W:05 Litter and illegal dumping

W:05 Litter and illegal dumping

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
151 survey sites primarily located across Melbourne suburbs **15 rural highway survey sites**	🟡	→	🔴	🟢	↗	🔴

Data source(s):	KAB, SV
Measure(s):	Number of litter items counted within defined survey sites

Why this indicator?

Litter and illegal dumping impact the health of humans, wildlife and ecosystems, as well as reducing aesthetic values. Problematic litter streams, particularly plastics, are non-biodegradable. They accumulate and persist as tiny fragments in the environment and are difficult to recover.

Criteria used for status assessment

No national or statewide standards, thresholds or strategic targets currently exist for litter and illegal dumping. The assessment in the SoE 2023 Report is based upon comparisons with the data used in determining the status and trend within the SoE 2018 Report.

Why this assessment in 2023?

Understanding the extent of litter and illegal dumping in Victoria is a challenge. Methodological limitations of surveys, particularly underrepresentation of non-urban sites, further constrains evaluating the extent of litter and dumping levels.

The amount of litter has been decreasing overall between 2009–10 and 2018–19 (latest data) but has seen slight increases beginning in 2017–18. During the most recent litter survey, the number of litter items declined from 5,398 litter items to 5,074 litter items across the 151 urban sites and from 112 to 108 items along the 15 rural highway sites. Beaches and parks had less volume of litter than sites within the built environment, suggesting that litter reduction campaigns targeted at coastal environments are effective in promoting behaviour change. Driving much of this observed decline in litter was a reduction in the number of cigarette butts.

Illegal dumping rates, on the other hand, have been on the rise since 2015–16, increasing from 18 Kt to 21 Kt by 2019–20 (most current data). The largest growth occurred in 2018–19, when the amount of litter dumped illegally spiked to 31 Kt, likely as a result of higher landfill levy costs and COVID-19 restrictions.

Summary of State of the Environment 2018 Report assessment

- Litter declined across years in Victoria from approximately 6,500 litter items in 2013-14 to approximately 4,200 litter items in 2016-17.
- The composition of litter streams remained consistent year-on-year, with cigarette butts being the dominant litter type each year.
- Litter was highest within built survey sites, particularly car parks and residential areas.
- A total of 25,788 tonnes of illegally dumped rubbish was collected by Victorian local governments in 2015-16, representing a 14% reduction from 2014-15.

Critical data used for the 2023 assessment

- National Litter Index 2018-2019: Victoria Results
- Litter Hotspots Report June 2019
- Waste and Recycling in Victoria: Local government Waste Services Report 2019-20

Waste and resource recovery

2023 assessment

Litter

Understanding the extent of litter and illegal dumping in the state is a challenge due to the diffuse nature of the problem. Litter often does not remain in the location it was disposed of, rather it is frequently transported via water and wind. Previously, the primary mechanism for capturing information on litter was through the National Litter Index. The National Litter Index has provided a consistent measure of litter since 2005. However, the data collection is limited to surveys conducted at 151 sites, primarily across Melbourne suburbs, with low representation of non-urban areas, although the breadth of survey sites was ultimately extended to include an additional 15 sites along regional highways.

Based on the available litter survey data (2009-10 to 2018-19), the overall number of litter items across the 151 urban sites has followed a general downward trend since 2009-10 (Figure W8). Despite continued reductions in total litter items year-on-year, the proportion of litter streams had remained relatively unchanged. Cigarette butts consistently were the largest litter type across years' while illegal dumping, plastic bags, and other glass litter types contributed the least. Rural highway sites, however, demonstrated a somewhat different pattern where the total number of litter items showed a dramatic decrease in 2011-12 then remained relatively stable until 2018-19 (Figure W9). Additionally, the composition of litter streams showed considerable variation across years. Cigarette butts and paper were the primary litter types in earlier survey years, while containers, paper and take-away litter items became more dominant in more recent surveys.

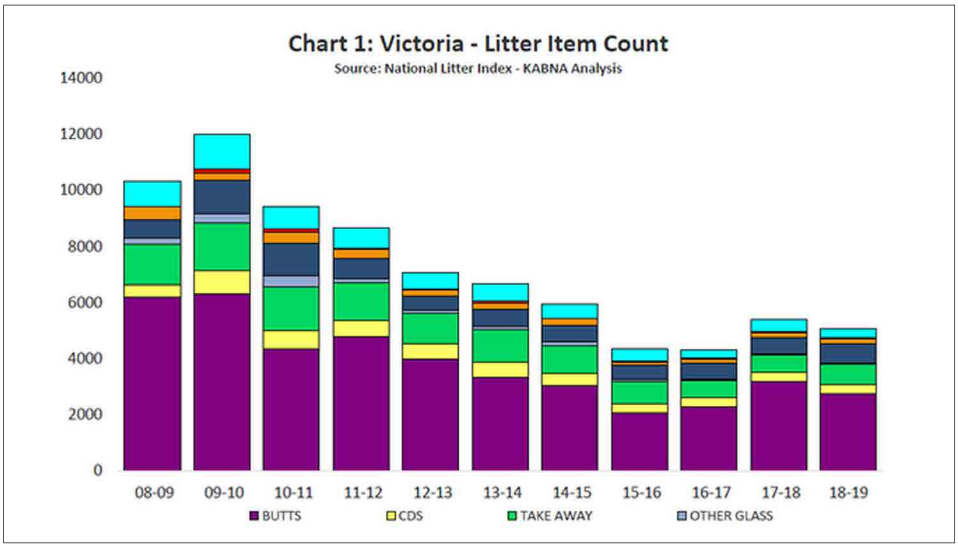


Figure W8: Litter counts by type across 151 urban sites in Victoria from 2008-09 to 2018-19.[2238]

[2238] Keep Australia Beautiful (KAB) 2019, 'National litter index 2018-2019: Victoria results', Newtown, New South Wales, https://assets.sustainability.vic.gov.au/susvic/Report-National-Litter-Index-2018-19-Victoria-results.pdf Accessed 14 July 2022.

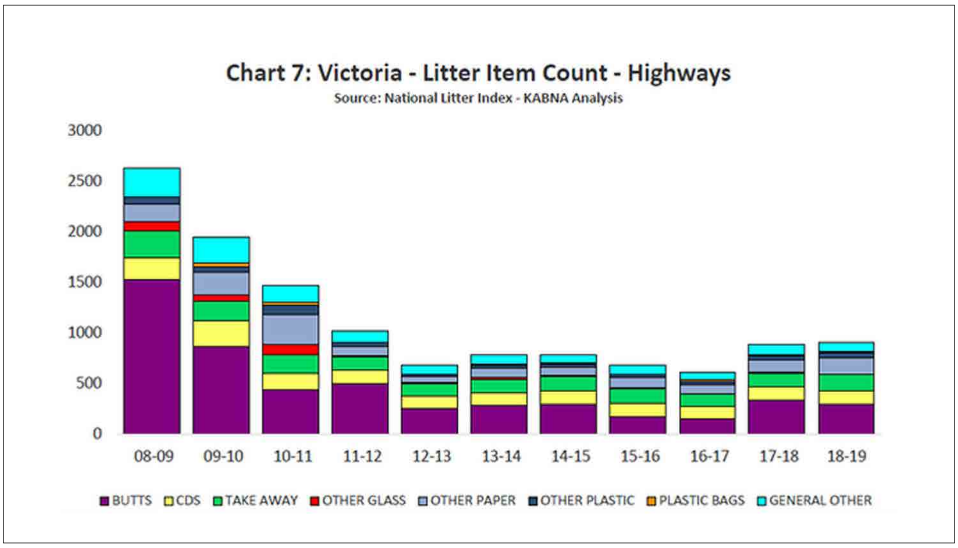


Figure W9: Litter counts by type across 15 rural highway sites in Victoria from 2008-09 to 2018-19.[2239]

In 2018-19 (most recent data), a total of 5,074 litter items were counted within the 151 urban sites, representing a 6% reduction from 2017-18 (Figure W8). This reduction was primarily due to a decrease in the number of cigarette butts, which also coincides with a decline in the smoking rate among adults in Victoria.[2240]

When considering the spatial area surveyed, natural settings (beaches and parks) had less litter per 1,000 m² than built environments, of which, retail precincts had the highest litter count as well as the greatest increase in litter items among all site categories. There was an average of 73 items recorded per 1,000 m², up from 58 items per 1,000 m² in 2017-18. Once again, cigarette butts were the dominant litter type recorded in this site category. By contrast, beaches saw the greatest reduction in litter items per 1,000 m², where the number of items dropped from 30 items to 20 items per 1,000 m². These results are further supported by audits conducted by the Caring for Our Bays, a litter hotspot program which not only monitors litter levels at 15 sites along the coastline of Port Phillip Bay but they also undertake education campaigns and perform large-scale clean-ups to remove litter from the sites.[2241] This downward trend in beach litter suggests that litter reduction campaigns targeted at coastal environments are working to change behaviour and improve litter levels in these regions.

For rural highway sites, the total number of litter items decreased from 112 items in 2017-18 to 108 items in 2018-19 (Figure W9). This represents a 4% reduction in the overall amount of litter items across the 15 sites. All litter waste streams saw a drop in the number of items counted except for takeaway food, beverage containers and general litter types. Take-away food litter had the largest increase (37%), growing from 27 items to 37 items, and made up the greatest proportion of litter waste along rural highway sites.

[2239] VicHealth 2022, 'Preventing tobacco use', https://www.vichealth.vic.gov.au/our-work/preventing-tobacco-use#:~:text=Adult%20smoking%20rates,socially%20and%20economically%20disadvantaged%20groups Accessed 11 September 2022.

[2240] Caring For Our Bays (CFOB) 2020, 'Litter hotspots report June 2019', Mannerim, Victoria.

[2241] Sustainability Victoria (SV) 2020, 'Victorian local government annual waste services report 2018-19', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Local-Government-Annual-Waste-Services-Report-2018-19.pdf Accessed 30 June 2022.

Illegal dumping

In addition to kerbside collections, local governments provide other waste management services which includes the clean-up of illegally dumped waste. The amount of waste that has been illegally dumped has been generally increasing overall. In 2015-16, local governments collected an estimated 18 Kt of illegally dumped waste which rose to 21 Kt by 2019-20. However, 2018-19 saw a sharp surge (56%) in the amount of material that was illegally dumped, where approximately 31 Kt of waste was cleaned up. This sudden spike has been partially attributed to the increased cost of the landfill levy during that time, while the subsequent decline in 2019-20 was likely due to stay-at-home orders under the state's COVID-19 restrictions.[2242, 2243] With the upward trend in collection services for illegally dumped waste material across the 5-year period came a greater financial burden to local governments, where the costs for providing litter maintenance services rose from $34 million to its highest of nearly $110 million in 2019-20, of which $10 million was spent on the clean-up for illegal dumping.[2244, 2245]

Pile of illegally dumped debris.
Credit: Gudella.

[2242] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.

[2243] Sustainability Victoria (SV) 2014, 'Victorian local government annual waste services report 2015-16: Other council services', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Victorian-Local-Government-Annual-Waste-Services-Report-2015-16-Other-council-services.docx Accessed 1 July 2022.

[2244] Sustainability Victoria (SV) 2021, 'Waste and recycling in Victoria: Local government waste services report 2019-20', Melbourne, Victoria, https://assets.sustainability.vic.gov.au/susvic/Report-Waste-Local-Government-Waste-Services-Report-2019-20.pdf Accessed 30 June 2022.

[2245] Blue Environment, Ascend Waste and Environment 2019 'Hazardous waste in Australia 2019', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/documents/hazardous-waste-australia-2019.pdf Accessed 1 August 2022.

Waste and resource recovery

Hazardous Waste

Indicator W:06 Total hazardous waste managed

W:06 Total hazardous waste managed

Regions(s)	2023 status	2023 trend	2023 confidence	2018 status	2018 trend	2018 data quality
Statewide	🔴	↙	🟡	🟡	→	🟡
Data source(s):	DCCEEW, EPA Victoria, SV					
Measure(s):	Hazardous waste arisings (tonnes) per year					

Why this indicator?

Hazardous waste contains contaminants that place the environment and human health at risk if inappropriately managed. Monitoring hazardous waste arisings is critical to identifying future infrastructure needs and ensuring that these materials are properly treated, recovered and disposed of.

Criteria used for status assessment

No national or statewide standards, thresholds or strategic targets currently exist for hazardous waste generation. Thus, the assessment in the SoE 2023 Report is based upon comparisons with the data used in determining the status and trend within the SoE 2018 Report.

Why this assessment in 2023?

Hazardous waste in Victoria has been increasing overall since 2010–11, from 9 Kt to its highest level of 1.72 Mt in 2019–20. The level of overall increase was higher during the SoE 2023 reporting period (24%) than that of the SoE 2018 reporting period (5%). Much of the upward trajectory in hazardous waste arisings in recent years has been driven by greater amounts of asbestos, waste oil/water and contaminated soils being generated and managed. By 2019–10, large-scale development projects, in particular Victoria's Big Build, resulted in unprecedented growth of contaminated soils, which became the largest single contributor (59%) to hazardous waste arisings in the state. The COVID-19 pandemic is also likely to have contributed to a steep rise in clinical waste from the healthcare and aged care sectors during 2019–20. The pandemic response resulted in greater interstate movement of hazardous waste in order to cope with the influx of personal protective equipment.

Recovery of hazardous waste has also been increasing. Recycling increased overall by 15% between 2014–15 and 2019–20. Contaminated soils demonstrated the strongest level of recovery among all hazardous waste categories in 2019–20, making up 26% of the total amount of hazardous waste recovered (192 Kt). Despite increasing recovery rates, growth in hazardous waste arisings resulted in a decrease in the proportion of hazardous waste that was recycled, declining from 19% to 11%.

Excessive stockpiling of hazardous waste proved to be a significant management challenge, leading to a high occurrence of emergency incidents between 2017 and 2019. Some incidents had significant public safety and environmental repercussions.

Summary of State of the Environment 2018 Report assessment

- Hazardous waste arisings in Victoria grew overall by 5% from 977 Kt to 1 Mt between 2012-13 and 2016-17.
- The greatest contribution towards the state's arisings in 2016-17 was from contaminated soils (452 Kt), asbestos (119 Kt) and grease trap waste (115 Kt).

Critical data used for the 2023 assessment

- Australian Hazardous Waste Data Compilation 2021

2023 assessment

Management of hazardous waste

In Victoria, hazardous waste was previously regulated as prescribed industrial waste under the Environment Protection (Industrial Waste Resource) Regulations 2009. These regulations were later replaced by the Environment Protection Regulations 2021, where hazardous waste is now being regulated as reportable priority waste. Unlike other classifications of waste which have relatively lower levels of risk, the EP Act applies additional duties and regulatory controls for reportable priority waste (hazardous waste herein) that dictate its management pathway. As such, the management of hazardous waste begins at the generating facility and continues through a series of treatment steps by various types of infrastructure to suitably reduce, contain, or immobilize its inherent risks to human health and the environment prior to the waste reaching its end fate which can include recycling, reuse, energy recovery, disposal, or long-term storage. Each of these facilities is required to have an EPA Victoria licence in place and adhere to its prescribed conditions, which includes strict storage limits and management of materials, while the vehicle transporting the waste must hold the appropriate permission to shift the waste between sites. As the waste moves along the management pathway, the waste producer (or appointed accredited consignor), transporter and receiving facility all have a duty to ensure that the hazardous waste is properly tracked by way of a waste transport certificate and that it is only received by a licensed facility. The waste transport certificates reflecting the type and amount of waste that is to be managed, termed arisings, is recorded within the EPA Victoria waste tracking system and may be counted multiple times if the waste is transported between different sites during its life cycle. Previously, the state's tracking system relied upon paper-based certificates, but these were ultimately replaced by an improved digital waste tracking system on 1 July 2021 under the EP Act. Statewide hazardous waste tracking data are also used at the national level towards reporting obligations set under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. As a signatory to the convention, the Australian Government is required to submit an annual report to the Basel Secretariat every calendar year detailing the tonnages of hazardous waste generated by each of its jurisdictions.

Stockpiling of hazardous waste is, however, not publicly disclosed in Victoria, nor is it captured by the state's hazardous waste tracking system as no off-site movement occurs to trigger the tracking obligation. It is important to note that stockpiled hazardous wastes are not tracked in real time by EPA Victoria. This means that there is a gap in understanding around the amount of stockpiled hazardous waste in the state, making routine site inspections and intelligence as the primary avenues for determining if licence conditions are being complied with. This information gap is further demonstrated within the annual reporting to the Basel Secretariat on generation of hazardous waste in Australia, where data on the amount of hazardous waste remaining onsite by way of stockpiling has been historically absent from annual reports and, where data have been provided by jurisdictions, it indicated that short-term storage was not necessarily short-term and, at times, was occurring at surprisingly high levels.[2246] This was also reiterated within the 2019 Legislative Council's Environment and Planning Committee inquiry report and prompted questions regarding the prevalence of excessive levels of stockpiling beyond licensing limits as well as whether stockpiling was occurring outside of the regulatory radar.[2247, 2248]

A significant number of major incidents occurred between 2017 and 2019 due to hazardous (and non-hazardous) waste either being illegally stored, over-stockpiled at licensed facilities, or stored in facilities which were not fit for purpose due to excessive and illegal stockpiling in Victoria.[2249, 2250]

2246. Legislative Council Environment and Planning Committee Parliament of Victoria 2019, 'Inquiry into recycling and waste management', Melbourne, Victoria, https://www.parliament.vic.gov.au/file_uploads/LCEPC_59-02_Inquiry_into_recycling_and_waste_management__6hNrvBj7.pdf Accessed 28 July 2022.
2247. Blue Environment, Ascend Waste and Environment 2019 'Hazardous waste in Australia 2019', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/documents/hazardous-waste-australia-2019.pdf Accessed 1 August 2022.
2248. Ibid
2249. Legislative Council Environment and Planning Committee Parliament of Victoria 2019, 'Inquiry into recycling and waste management: Interim report', Melbourne, https://new.parliament.vic.gov.au/4af1cc/contentassets/631c8359ad7f4dc487aef9d986fae1e7/interim-report-inquiry-into-recycling-and-waste.pdf Accessed 28 July 2022.
2250. Legislative Council Environment and Planning Committee Parliament of Victoria 2019, 'Inquiry into recycling and waste management: Interim report', Melbourne, https://new.parliament.vic.gov.au/4af1cc/contentassets/631c8359ad7f4dc487aef9d986fae1e7/interim-report-inquiry-into-recycling-and-waste.pdf Accessed 28 July 2022.

One such incident was a catastrophic fire at a West Footscray warehouse in 2018 which erupted due to the illegal stockpiling of hazardous chemicals.[2251] The emergency response was one of the largest since 1991, lasting several days and requiring over 100 firefighters to fully control the fire. The incident not only resulted in emergency orders being issued to several neighbouring communities due to poor air quality, but also caused severe environmental impacts, including wildlife mortality and the pollution to Stony Creek. Following the fire, authorities also discovered an estimated 19 tonnes of illegally stockpiled hazardous chemicals in eight other warehouses which were reportedly linked to the same operator responsible for the West Footscray industrial fire.[2252] In response to the pervasiveness of hazardous waste incidents across the state, WorkSafe and EPA Victoria had increased the level of compliance checks, with facilities subject to high levels of storage being particularly targeted.

Transparency in reporting of stockpiles is a widespread issue across Australian jurisdictions including Victoria, with the national hazardous waste report recommending that regulators consider the requirement for monthly reporting by facilities on the volume of stored waste that would then be built into the hazardous waste tracking system.[2253] Implementing this recommendation, although costly, would work towards not only ensuring that hazardous waste stockpiling is fully disclosed and regulatory controls are complied with, but could also act in reducing the occurrence of, and impacts from, illegal and unlicensed incidents in the state which are still being discovered.[2254]

Another hazardous waste issue that is deserving of more attention is the management of plastics. Plastics are used extensively across a range of products and applications which can be attributed to the additive chemicals which improve their flexibility, form, and/or stability. Although, some of the additives contained within plastics have been proven to negatively impact on some health indicators.[2255] The chemical additives receiving the most scrutiny are those known to be endocrine disrupting chemicals that can be found in everyday items like beverage containers, food storage containers, food packaging, personal care products, and toys.[2256] Despite a breadth of toxicology science, household plastics are classified as solid waste in Australia. Although some plastics have become presumed hazardous as of 2021 and are subject to the Basel Convention's control of transboundary movements between parties, but further regulatory controls would be needed. The policy environment around plastics is complicated by the fact that most chemical additives are added overseas prior to importing the plastic material, making regulatory controls difficult.[2257]

As Victoria transitions to a circular economy, there is a critical need for the presence of hazards within waste to be fully understood and be designed out of products to avoid downstream environmental impacts.[2258, 2259]

Hazardous waste arisings

Nationally, the rate of growth in hazardous waste is greater than for non-hazardous waste. When expressed as a total increase from 2006-07 to 2019-20, hazardous waste had risen by 54% in Australia, while non-hazardous waste only rose by 18%.[2260] Victoria showed a similar pattern where hazardous waste arisings had shown overall growth since 2010-11, except during 2018-19 where arisings declined by 13% (Figure W10). Much of this overall upward trajectory in the state was driven by greater amounts of asbestos, waste oil/water and contaminated soils being generated and managed. In 2019-20, an estimated 1.7 Mt (excluding biosolids)

[2251] Anthony Colangelo 2019, 'Like Jenga: Complex, toxic chemical clean-up begins in Melbourne warehouse', The Age, https://www.theage.com.au/national/victoria/complex-chemical-stockpile-clean-up-20190206-p50vye.html Accessed 1 August 2022.

[2252] Blue Environment, Ascend Waste and Environment 2019 'Hazardous waste in Australia 2019', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/documents/hazardous-waste-australia-2019.pdf Accessed 1 August 2022.

[2253] Chris Vedelago 2021, 'Stockpile of flammable, explosive waste found near homes and major highway', The Age, https://www.theage.com.au/national/victoria/stockpile-of-flammable-explosive-waste-found-near-homes-and-major-highway-20210407-p57h1w.html Accessed 24 January 2023.

[2254] Blue Environment, Ascend Waste and Environment 2021, 'Hazardous waste in Australia 2021', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/documents/hazardous-waste-australia-2019.pdf Accessed 5 July 2022.

[2255] Ibid.

[2256] Ibid.

[2257] Ibid.

[2258] Ibid

[2259] Blue Environment 2020, 'National waste report 2020', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-report-2020.pdf Accessed 4 July 2022.

[2260] Blue Environment, Ascend Waste and Environment 2021, 'Hazardous waste in Australia 2021', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/documents/hazardous-waste-australia-2019.pdf Accessed 5 July 2022.

of hazardous waste was managed, making Victoria the jurisdiction with the second highest level of hazardous waste arisings in Australia.[2261] Over 30 different types of hazardous waste were managed, of which seven waste types accounted for nearly 90% of total arisings (Figure W11). Contaminated soils were by far the largest single contributor (59%) of hazardous waste streams in the state that year. Increasing by 42% since the previous year (2018-19), growth in contaminated soil was unprecedented and was likely a reflection of the large-scale development occurring in the state, primarily road and rail projects associated with Victoria's Big Build.[2262]

Despite the toxic nature of hazardous waste, recovery is still possible for some types of hazardous waste that are not of the highest level of hazard (Category A). Recycling has demonstrated an overall rise since 2014-15, where the recovery of hazardous waste materials increased by 15% as of 2019-20. However, the proportion of hazardous waste arisings that was recycled decreased from 19% to 11% during the same period. In 2019-20, 192 Kt of the 1.7 Mt of hazardous waste was recovered while 1.4 Mt (83%) was disposed of following treatment. Overall recovery was highest for contaminated soils at 49 Kt.

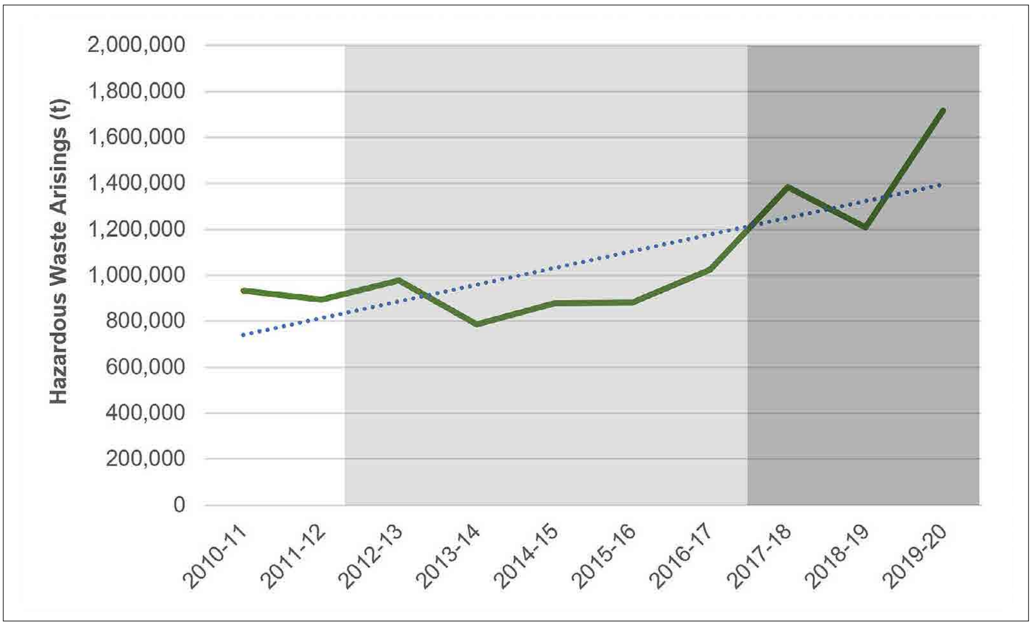


Figure W10: Total hazardous waste arisings in Victoria from 2010-11 to 2019-20.[2263] Dotted line represents the overall trend. Light and dark grey time series represents the SoE 2018 and SoE 2023 reporting periods, respectively.

2261. Blue Environment 2020, 'National waste report 2020', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-report-2020.pdf Accessed 4 July 2022.
2262. Blue Environment 2020, 'National waste database 2020', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-database-2020.xlsx Accessed 5 July 2022.
2263. Blue Environment 2020, 'National waste database 2020', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-database-2020.xlsx Accessed 5 July 2022.

Waste and resource recovery

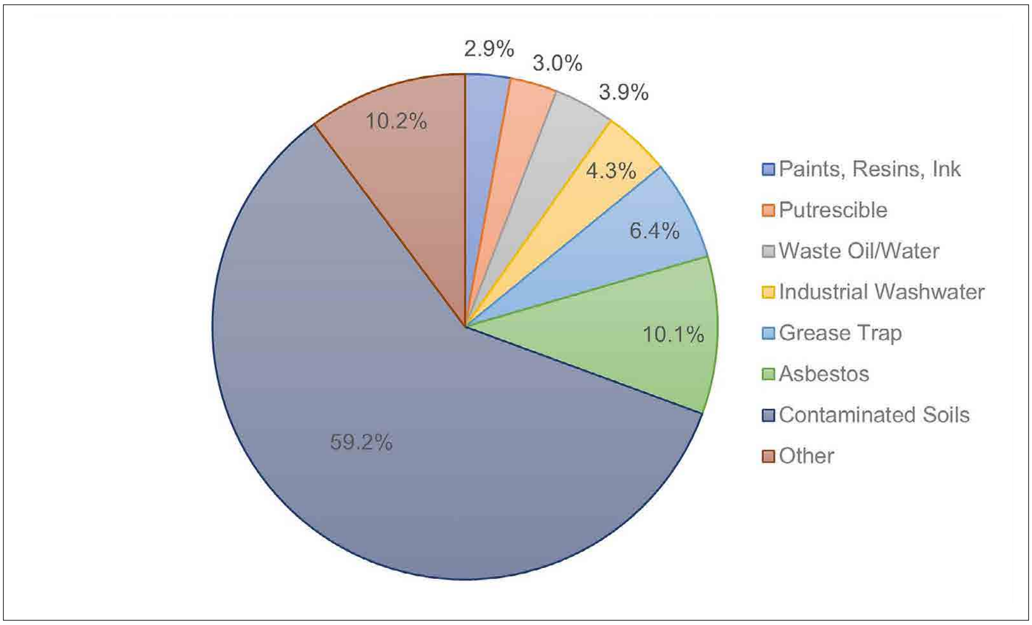


Figure W11: Proportion of hazardous waste arisings in Victoria during 2019-20.[2264] The waste stream indicated as other refers to clinical and pharmaceutical waste, non-toxic salts, mercury and zinc compounds.

Although the dominant source sector of hazardous waste is the C&D sector, households also produce a considerable amount of hazardous waste. Much of this waste is in the form of household cleaners, motor oil, paints and solvents, automobile batteries, and pesticides. Victoria has put into place several community programs, such as Paintback and Detox Your Home, which collects and appropriately recovers hazardous products so that they do not end up in landfill, the sewage system or illegally dumped prior to treatment. Comprehensive data on the amounts and types of hazardous materials collected under each of these programs is lacking, but a few reports do offer some insights. The National Waste Report, for example, indicated that 179 tonnes of municipal hazardous waste (excluding paint) were collected in 2018-19, and later in 2020-21 some 78 tonnes of household chemicals were collected through Detox Your Home events, including 36,361 kg of flammable liquids and more than 12,000 kg of pesticides.[2265, 2266]

Emerging as a major waste stream among households is waste from electronic products, referred to as e-waste. E-waste is growing up to three times faster than general municipal waste as a result of:

- rapid innovation prompting more frequent product replacement
- built-in product obsolescence resulting in shorter lifespans of electronic products
- complex product design which reduces repair and recovery options
- increased affordability enabling higher accessibility and reducing the incentive for repairing products.

[2264] Blue Environment 2020, 'National waste database 2020', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-database-2020.xlsx Accessed 5 July 2022.

[2265] Ibid.

[2266] Department of Environment, Land, Water and Planning (DELWP) 2021, 'Sustainability fund activities report 2020-21', Melbourne, Victoria, https://www.parliament.vic.gov.au/file_uploads/DELWP0202_SustainabilityFund_2020_2021_ActivitiesReport_v8_nLQZTXBX.pdf. Accessed 29 July 2022.

Collectively, these factors work in reinforcing the trend towards a higher turnover of electronic products and, consequently, greater e-waste volumes. This is clearly demonstrated by the national data on e-waste generation (no data available for only Victoria) which showed a 4% increase during 2018-19, to reach an estimated 539 Kt.[2267] Looking forward, the waste arising from televisions and computers alone is predicted to grow by over 60% by 2024, while it is estimated that 26,000 tonnes of solar panels will be reaching their end of life come 2035 and entering Victoria's waste stream annually, eclipsing all other e-waste streams.[2268, 2269, 2270]

The issue around e-waste is not only the surge in its generation, but also the potential environmental risks associated with its disposal or mismanagement. E-waste contains materials like lead, mercury, ozone-depleting chlorofluorocarbons, and flame retardants which are all hazardous and do not readily break down. Even small amounts of these hazardous materials can result in long-term environmental contamination and severe impacts on human health.[2271] What's more, the disposal of e-waste also means that the valuable metals which make up these products are lost, which has upstream impacts in that further extraction of virgin resources are required to meet the demand for manufacturing new electronic products. Recognizing the lost opportunity of disposing e-waste, and the impacts that ensue when this waste enters the environment, the Victorian Government has listed this waste stream as priority waste and has placed a ban on e-waste from being sent to landfill, which was put into effect in 2019.

But even prior to the landfill ban, reprocessors viewed the growing supply of e-waste as an opportunity, an 'urban mine' of valuable recyclable materials to be exploited. This had prompted the number of reprocessing organizations in the country to nearly double, while the number of programs and policies that support the recovery and appropriate management of electronic products had also increased. Among these initiatives are e-waste product stewardship schemes administered by the Australian Government, like the National Television and Computer Recycling Scheme and B-cycle, which act to improve viable material recovery by alleviating one of the major contributing factors towards the growing e-waste issue which is product design. In requiring manufacturers and importers to take a shared responsibility for the end-of-life treatment of their products, the true costs of reuse, recovery, or disposal are integrated within the cost of production. This leads to products that are designed in a way which promotes their recovery and is essential to the successful transition to a circular economy. Within Victoria, grants are available under the circular economy policy to support businesses in the delivery of product stewardship arrangements. Although no state-level data are available to indicate the volume of e-waste that has been collected and recycled through the existing product stewardship schemes, it has been reported that on a national level the National Television and Computer Recycling Scheme has resulted in an estimated 290 Kt of e-waste being diverted from landfill since 2011.[2272]

Despite the positive trend of strengthening recovery, however, the opportunities for recycling are still currently limited for some types of e-waste, like solar panels where less than 20% of the components can be reprocessed in Australia. This is a growing concern given the volume that is expected to require management in the coming years. A national approach is currently being developed by SV, in collaboration with other state and territory governments as well as businesses and industry stakeholders, to improve the management of photovoltaic systems, particularly solar panels, and increase the opportunity to reuse their valuable materials.

2267. Blue Environment 2020, 'National waste report 2020', Report prepared for the (now) Department of Climate Change, Energy, the Environment and Water (DCCEEW), https://www.dcceew.gov.au/sites/default/files/env/pages/5a160ae2-d3a9-480e-9344-4eac42ef9001/files/national-waste-report-2020.pdf Accessed 4 July 2022.

2268. Sustainability Victoria (SV) 2017, 'Managing e-waste in Victoria', Melbourne, Victoria, https://www.environment.vic.gov.au/__data/assets/pdf_file/0026/408347/Managing-e-waste-in-Victoria-PIA-PDF.pdf Accessed 1 August 2022.

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2270. ABC News 2023, 'Solar panels are leading the clean energy revolution, but recycling them isn't easy', https://www.abc.net.au/news/2023-01-22/solar-panel-recycling-nano-silicon-extraction/101865624 Accessed 27 January 2023.

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2272. Department of Environment, Land, Water and Planning (DELWP) 2020, 'Recycling Victoria: A new economy', Melbourne, Victoria, https://www.vic.gov.au/sites/default/files/2020-02/Recycling%20Victoria%20A%20new%20economy.pdf Accessed 30 June 2022.

Abbreviations

AANP	Australian Alps National Parks
AAP	adaptation action plan
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABC	Australian Broadcasting Corporation
ABS	Australian Bureau of Statistics
ACCU	Australian Carbon Credit Unit
ACORN-SAT	Australian Climate Observations Reference Network – Surface Air Temperature
ACU	Australian Catholic University
AgVic	Agriculture Victoria
ANCHORS	Australian National Collection of Homogenized Observations of Relative Sea Level
APACs	Air pollution assessment criteria
ARI	Arthur Rylah Institute
ARV	Alpine Resorts Victoria
AWA	Aboriginal Waterway Assessments
BBRR	Bushfire Biodiversity Response and Recovery
BOM	Australian Bureau of Meteorology
BSUD	biodiversity-sensitive urban design
C&D	construction and demolition
C&I	commercial and industrial
CaLP Act	*Catchment and Land Protection Act 1994*
CAPAD	Collaborative Australian Protected Areas Database
CAR	comprehensive, adequate and representative
CC Act	*Climate Change Act 2017*
CES	Commissioner for Environmental Sustainability Victoria
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
CFA	Victorian Country Fire Authority
CFC	chlorofluorocarbon
CGRSWS	Central and Gippsland Region Sustainable Water Strategy
CIP	Coupe Inspection Program
CMA	Victorian Catchment Management Authority
CO2-e	carbon dioxide equivalent
COP26	Conference of the Parties 26
CR	Conservation Regulator
CRC	Cooperative Research Centre

Abbreviations

CSIRO	Commonwealth Scientific and Industrial Research Organisation
dB	decibel
DCCEEW	Commonwealth Department of Climate Change, Energy, the Environment and Water
DEECA	Victorian Department of Energy, Environment and Climate Action (formerly DELWP prior to 1 January 2023)
DELWP	Victorian Department of Environment, Land, Water and Planning (now DEECA as of 1 January 2023)
DEPI	Victorian Department of Environment and Primary Industries
DHHS	Victorian Department of Health and Human Services
DJCS	Victorian Department of Justice and Community Safety
DJPR	Victorian Department of Jobs, Precincts and Regions (now DJSIR as of 1 January 2023)
DPC	Victorian Department of Premier and Cabinet
DSE	Victorian Department of Sustainability and Environment
DTP	Victorian Department of Transport and Planning
EBA	ecosystem-based adaptation
EC	electrical conductivity
EFG	ecological fire groups
EIA	environmental impact assessment
EMV	Emergency Management Victoria
EP Act	*Environment Protection Act 2017*
EPA Victoria	Environment Protection Authority Victoria
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPCE	Eminent Panel for Community Engagement
ERF	Emission Reduction Fund
ERS	Environment Reference Standard
EVC	ecological vegetation class
EWAP	Environmental Water Action Plan
EWR	Environmental Water Reserve
FAP	Forest Audit Program
FFDI	forest fire danger index
FFG Act	*Flora and Fauna Guarantee Act 1988*
FMP	forest management plan
FOGO	food organics and garden organics
FRD	Financial Reporting Directive
FRV	Fire Rescue Victoria
FT	full-time equivalent
g CO2/km	grams CO2 per kilometre

Abbreviations

G20	Group of Twenty
GDE	groundwater-dependent ecosystem
GHG	greenhouse gas
GIS	geographic information system
GL	gigalitre
GM2030	Groundwater Management 2030
GMA	groundwater management area
GMU	groundwater management unit
GMZ	general management zone
GORCP	Great Ocean Road Coast and Parks
GQRUZ	groundwater quality restricted use zone
GSP	gross state product
GSS	growth stage structure
GW	gigawatt
ha	hectare
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
IFER	Integrated Forest and Ecosystem Research
IHD	ischemic heart disease
IMOS	Integrated Marine Observing System
IPA	immediate protection area
IPAF	Invasive Plants and Animals Policy Framework
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IV	Infrastructure Victoria
IWH	instream woody habitat
IUCN	International Union for the Conservation of Nature
IWM	Integrated Water Management
JFMP	Joint Fuel Management Program
KAB	Keep Australia Beautiful
kg	kilogram
km	kilometre
Kt	kilo-tonne
LAC	limit of acceptable change
LED	light emitting diode

Abbreviations

LGA	local government area
LGWSR	Local Government Waste Services Report
LTWRA	Long Term Water Resource Assessment
LULUCF	land use, land-use change and forestry
m3	cubic metre
MACKF	Marine and Coastal Knowledge Framework
MDBA	Murray-Darling Basin Authority
MER	monitoring, evaluating and reporting
MERF	monitoring, evaluation and reporting framework
MERI	monitoring , evaluation, reporting and improvement
ML	megalitre
MSW	municipal solid waste
Mt	mega-tonne
MtC	million tonnes of carbon
MW	megawatt
MWh	megawatt hour
µg	microgram
µS/cm	microseimens per centimetre
NCIS	National Coronial Information System
NEM	National Electricity Market
NEPM AAQ	National Environment Protection (Ambient Air Quality) Measure
NFI	National Forestry Index
NHRA	Natural Hazards Research Australia
NOAA	National Oceanic and Atmospheric Administration
NRM	natural resource management
NTU	nephelometric turbidity unit
OECD	Organisation for Economic Co-operation and Development
P&E Act	*Planning and Environment Act 1987*
PCV	permissible consumptive volume
PFAS	per- and poly-fluoroalkyl substance
PJ	petajoule
PM_{10}	particles less than 10 micrometres in diameter
$PM_{2.5}$	particles less than 2.5 micrometres in diameter
ppm	parts per million
PRSA	preliminary risk screen assessment

Abbreviations

PSR	Priority Sites Register
PV	Parks Victoria
QUT	Queensland University of Technology
RAS	Regional Adaptation Strategy
RCP	representative concentration pathway
RECP	Regional Circular Economy Plan
REZ	Renewable Energy Zone
RFA	Regional Forest Agreement
RIWR	Recycling Industry Waste Report
RLP	regional land partnerships
RMIT	Royal Melbourne Institute of Technology
RO	resource outlook
RV	Recycling Victoria
RWMP	Regional Water Monitoring Partnerships
SA2	Statistical Area 2
SA4	Statistical Area 4
SDG	sustainable development goal
SEC	State Electricity Commission
SEPP	State Environment Protection Policy
SES	Victorian State Emergency Service
SMP	Strategic Management Prospects
SMZ	special management zone
SNA	System of National Accounts
SOC	soil organic carbon
SoE	State of the Environment
SPZ	special protection zone
SV	Sustainability Victoria
SWRRIP	Statewide Waste and Resource Recovery Infrastructure Plan
t	tonne
TCFD	Taskforce on Climate-related Financial Disclosures
TFI	tolerable fire interval
TLM	The Living Murray
TRP	Timber Release Plan
TSCRA	Threatened Species and Communities Risk Assessment
TVC	total vegetation cover

Abbreviations

UHI	urban heat island
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UV	ultraviolet radiation
UWS	Urban Water Strategies
VAGO	Victorian Auditor-General's Office
VEAC	Victorian Environmental Assessment Council
VEFMAP	Victorian Environmental Flows Monitoring and Assessment Program
VEWH	Victorian Environmental Water Holder
VFMP	Victorian Forest Monitoring Program
VFP	Victorian Forestry Plan
VicWaCI	Victorian Water and Climate Initiative
VIIRS	visible infrared imaging radiometer suite
VNI	Victoria-New South Wales Interconnector
VOC	volatile organic compound
VPC	Victorian Plantations Corporation
WetMAP	Wetland Monitoring and Assessment Program
WMIS	Water Measurement Information System
WQI	water quality index
WSPA	water supply protection area
YSP	Yarra Strategic Plan
YLL	years of life lost
ZEV	zero emissions vehicle

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